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An Analytic Process Model for Systems Design and Measurement

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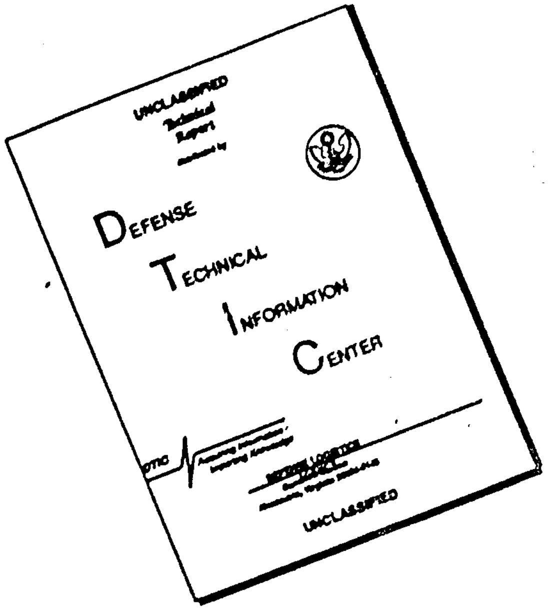

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this model development effort is to provide a uniform, thorough, adaptive and efficient procedure to help derive design specifications and effectiveness measures for any planned or existing human-machine system, especially a training system. ~~The present~~ This report describes results of the second year of work, in which the analytic process model (APM) was developed in greater detail, applied in a sample fashion to an existing system (the Bradley Infantry Fighting Vehicle Training System) and a newly planned system (the Army 9mm Handgun Training System, and placed onto an Apple II computer for demonstrating

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its potential for computer-aided applications. The sample applications and procedures are documented, and recommendations are made to complete development of the model, its application procedures, and the manner of its dissemination to Army users. Keywords: Computer aided design

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I. INTRODUCTION

This report describes results of the second year's work on an analytic process model (APM) for systems design and measurement. The work was completed by Dunlap and Associates, Inc., under contract MDA903-80-C-0315* between the U.S. Army Research Institute for the Behavioral and Social Sciences (Fort Benning Field Unit), and the Mellonics Systems Development Division of Litton Systems, Inc. Task 3 (System Development and Evaluation Technology) of that contract was performed by Dunlap under a subcontract (No. 05628) from Litton Mellonics.

During the second year this task has been directed primarily toward demonstrating that the APM, as originally designed for systems measurement[1], could be applied successfully to the analysis and evaluation of training systems. This has been done in the context of the Bradley Infantry Fighting Vehicle Training System (BIFVTS). The project staff also explored the use of the APM, and its component systems taxonomy model (STM), as a design tool for the specification of training systems required to support developing systems. This design application of the APM was examined in the context of a training system for the new (to be selected) 9mm Army handgun. The third major activity during year 2 was to examine the potential for computer-aiding the APM application procedure. For that effort, a sample application of the APM was programmed on an Apple II computer, in order to demonstrate an ability to automate the routine procedures as an interactive analytic process, thereby making the APM application a cost-effective and efficient technique.

The rationale behind the work on this project rests with the problem that testers, analyzers and researchers too often use an incomplete or inappropriate set of human performance measures in evaluating or specifying a human-machine (e.g., training) system. Those are usually known measures often selected without adequate consideration of the system context, which may not help clearly assess system performance and may not provide adequate answers to the essential questions about system effectiveness. Because there is no verified analytic process for deriving (or specifying) the optimal measures of a system's performance or effectiveness, true assessment needs are difficult to define and the process is relatively haphazard. The typical solution is to test/measure/specify the easy and accessible system points, but not necessarily those that should be addressed. Without having more systematic procedures, people measure or specify what can be counted (e.g., POI hours), or observed (e.g., number of troops trained). They design written tests to assess facts rather than understanding, and use criteria such as end-of-course tests rather than on-the-job performance. Rarely do people know the relationship between test performance and job performance, or between soldier job performance and unit effectiveness.

*Contract Title: "Effectiveness of Infantry Systems: TEA, CTEA, and Human Factors in Systems Development and Fielding."

[1] Bloom, R.F., Oates, J.F., Jr. and Hamilton, J.W. An Initial Analytic Process Model for Systems Measurement: Extensions of the Systems Taxonomy Model. Darien, CT: Dunlap and Associates, Inc., 30 April 1981. (Final Summary Report).

POI hours), or observed (e.g., number of troops trained). They design written tests to assess facts rather than understanding, and use criteria such as end-of-course tests rather than on-the-job performance. Rarely do people know the relationship between test performance and job performance, or between soldier job performance and unit effectiveness.

The results of those inadequacies of the measurement determination process are the wasting of valuable resources (time, effort, talent, money), the failure to provide adequate answers to effectiveness questions, and the relegation to obscurity of the elusive questions regarding human contributions to system performance. A better method is required to decide what should be measured and how. Hence, the development of this analytic process model for system design and measurement.

The APM is intended to enable testers, analysts and researchers to define system factors or taxonomies, and to translate taxa into measures or design requirements. The model forces one to describe the system of interest and its human elements in such a way as to suggest a more complete set of system-human attributes pertinent to system effectiveness. The model aids the users by providing general "menus" of factors (taxa), and procedures to help translate those taxa into appropriate measures or design requirements. The APM for measurement is illustrated in Figure 1 (the APM for design has not yet been defined this completely). The five blocks (numbers 1 through 5) across the top of Figure 1 comprise the most highly developed portion of the model, and are often referred to as the systems taxonomy model (STM). During this second year of work, more development effort than before was applied to blocks 6 and 7 in an attempt to implement more completely what is considered to be the basic mission of the model under the present contract--routinizing the derivation of appropriate measures and design requirements. The remaining blocks of Figure 1 (numbers 8 through 17) have received little attention in this study because our present objectives of developing procedures for deriving the required information are met if one can complete the model steps through block 7. The APM for design specification is most similar to the measurement version (Figure 1) in the early stages (taxonomy development), and becomes less similar in the later stages.

Details of the APM and significant accomplishments in its continuing development and application are described in the following chapter. Specific applications of the model to training systems, and their measurement and initial design are described in the later chapters. Following that is a description of the computer-aided application of the model and future plans.

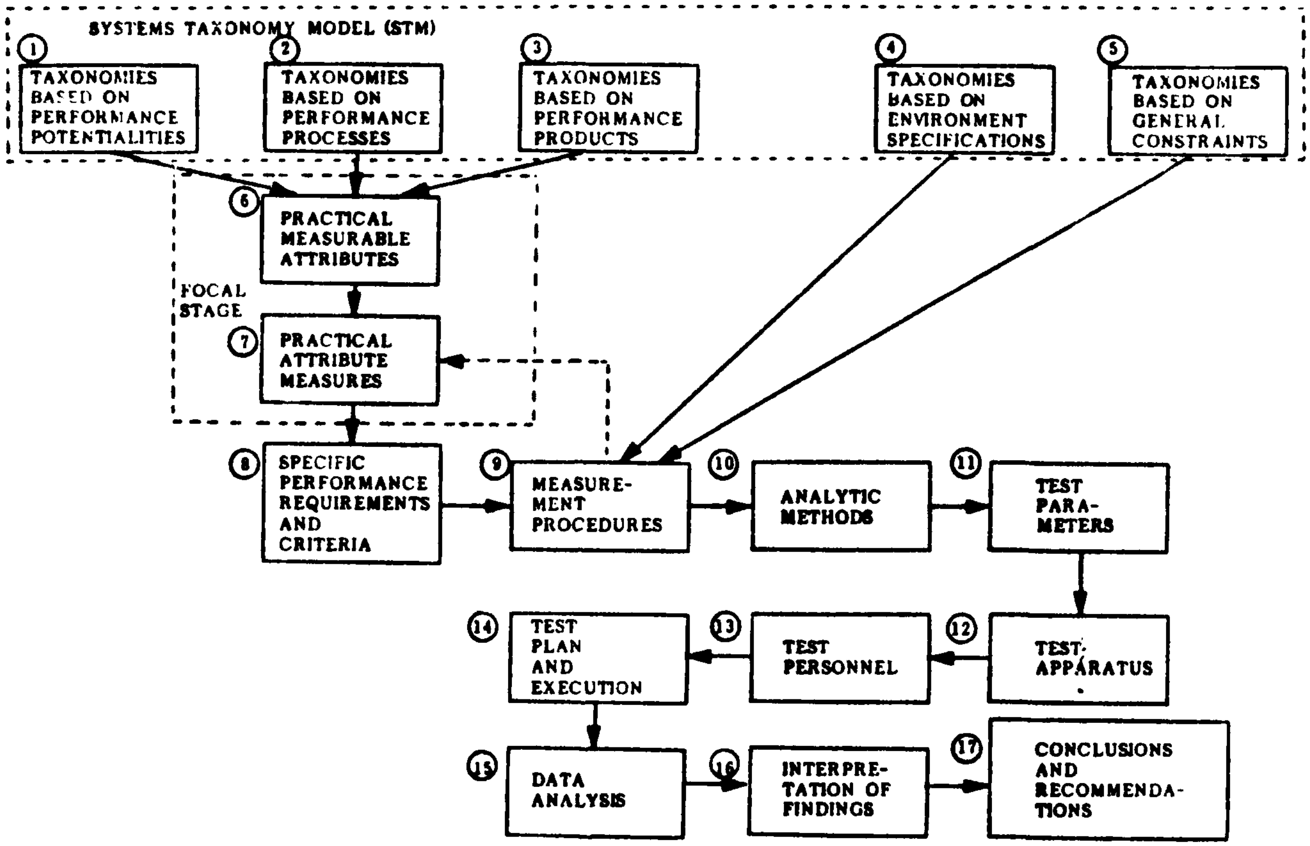

Figure 1. The Analytic Process Model for Measurement

II. THE ANALYTIC PROCESS MODEL (APM)

A brief summary of significant APM concepts, definitions and development milestones are provided here as a departure point for the reader in reviewing the results of our second year's work.

A. Initial APM Concepts and Definitions

The initial work on manned system measurement and the systems taxonomy model by Finley and her colleagues[1,2] indicated that certain prerequisites exist for including "system" factors in manned system performance measurement. They are: (1) recognition of systems as viable entities in and of themselves; and (2) development of conceptual tools for the purpose of grouping systems into populations, defining these populations, and placing them into a context with other populations.

In all cases, a taxonomy supplies knowledge that is specifically relevant to the analytic application at hand. Thus, each system taxonomy is unique to the particular system and to the particular context and purposes in and for which the measurement or design process is to be applied. What Finley et al. sought was a systematic way of generating such taxonomies for any given system and analytic purpose. Development of the STM and its encompassing APM by the Dunlap staff in the current project was intended to help meet that need. A description of work completed during the first year of this project is found in Bloom, et al. (1981)[3], and is summarized below. The reader will note that the emphasis in this early APM development work has been on the STM portion. Later stages of the APM are addressed in the second year's effort.

First, system populations can be formed according to a context factor consisting of the following: the kind of system each population member is supposed to be; the kind of mission or job each member is supposed to be able to do; the circumstances, conditions, and constraints under which each member is supposed to work; the specific requirements and criteria each member is supposed to satisfy; etc. Each such population immediately suggests design and measurement issues, such as: Is the system what it is supposed to be? Can it do what it should? Will it work where it is supposed to?

[1] Finley, D.L., Muckler, F.A., Gainer, C.A. and Obermayer, R.W. An Analysis and Evaluation Methodology for Command and Control: Final Technical Report. Northridge, CA: Manned Systems Sciences, Inc., November 1975.

[2] Finley, D.L. and Muckler, F.A. Human Factors Research and the Development of a Manned Systems Applications Science: The System Sampling Problem and a Solution. Northridge, CA: Manned Systems Sciences, Inc., July 1976.

[3] Bloom, et al., 1981. Op. Cit

A second factor by which any system can be examined is that of descriptive level, which refers to the several levels of increasing detail into which a system can be divided. First, a system can be described as an indivisible, macroscopic entity, or "black box." This overall level of description can be thought of as focusing on the system's basic objectives. Taxa that would be identified on that level of description would be expected to generate nominal specifications or taxa of performance/effectiveness, and would tend to be particularly directed to generalizable research issues. Second, the system can be described in more detailed terms of how it can be applied, i.e., its functional purposes. This level of description probably would produce taxonomies directed to both fundamental and system-specific types of research questions, and would generate both nominal and relative measures. Third, a system can be described in terms of how it can achieve its purposes, i.e., in terms of the characteristics of its operations. This level of description would tend to yield relative measurements, and be applicable mainly to specific research issues. The distinction between generic and specific research issues will be illustrated later in Section III (Figure 13).

These first two factors (system context and levels) suggest a descriptive matrix for the model, which in its rudimentary form served as a point of departure for the work under this contract. In its subsequent, evolved form, shown in Figure 2, the matrix served as a point of departure for the second year's work.

Because any system tends to be associated with larger and smaller systems in carrying out its operations, that system of interest must be viewed in terms of those operating relationships. Consequently, a third factor of the APM is the hierarchical structure of system operation, illustrated in Figure 3. This third factor is intended to insure that proper attention to interacting entities is given in any system design or measurement process. The hierarchical structure includes every system with which the system of interest directly interacts. In general, a system interacts directly with:

- Larger systems, of which it is a part, and superior systems, to which it is subservient in a command/control sense; collectively, these larger and/or superior systems are termed suprasystems in the hierarchical structure.

- Smaller systems that comprise it, and inferior systems over which it exercises command/control; collectively, these are termed subsystems.

- Systems that exist and operate on their own level of command and control, with which they share resources and/or exchange input/output; collectively, these are called collateral systems.

When the two-factor matrix (Figure 2) is applied to the system of interest and its associated hierarchy, the model takes on a three-factor appearance as shown in Figure 4. Each cell of each matrix of Figure 4 yields a list or

DESCRIPTIVE LEVELS OF SYSTEM OPERATION	CONTEXT OF SYSTEM OPERATION				
	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS	ENVIRONMENT SPECIFICATION	GENERAL CONSTRAINTS
OBJECTIVES (What?)	"The system must be capable of..." What must this system be capable of doing or providing? What kinds of services must it be able to provide? What needs is this system supposed to fulfill? Example. For a military training system: What are the capabilities needed to administer, develop, prepare for, deliver and support training?	"The system must carry out the following activities..." What jobs are required of this system? What procedures are involved in this mission? What assignments does this system receive to support higher command?	"The system must produce..." What products must the system deliver in the course of this mission? What goods or services must it output? What results are being sought?	"The system must operate under the following conditions..." What naturally occuring factors may affect the system's work? What elements of the environment might affect the system's potentialities, processes, or products?	"The system must operate under the following restrictions..." What factors affecting the system's work have been imposed by doctrine or other intervention?
FUNCTIONAL PURPOSES (Why?)	"This particular capability must allow the system to be able to..." What are the purposes to which each potentiality might be applied? How is the system supposed to use its capabilities? Where specifically do its needs arise?	"The reasons for carrying out this particular activity are..." What are the purposes for doing each job? Why have the assignments been given? What are the reasons for implementing the procedures?	"This particular product will be used by the system to..." What benefits can be derived from the results? How will the system use what it produces?	"The system's purposes must be satisfied in the face of..." What environmental factors might affect the applications of the system's potentialities, processes, or products?	"The system's purposes must be satisfied in the face of..." How might the imposed factors influence the purposes to which the system's potentialities, processes, or products may be put?
CHARACTERISTICS (How?)	"To satisfy this particular application, the system must have the ability to..." What specific abilities are needed to serve each purpose? What different capabilities can be brought to bear on each application?	"The tasks required to satisfy the particular purpose are..." What steps must the system take in order to accomplish the applications? In what different ways can the system carry out its assignments?	"To achieve that benefit, the system first must produce..." What milestones have to be achieved to realize the benefit? What intermediate goods and services are needed to deliver the finished product? What are the stepping stones toward the desired output?	"The constituent abilities, procedures, and milestones may be affected by..." How might the environment impact on the abilities, procedures, or intermediate results? What are the specific influencing factors in the environment? How should the system respond to those factors?	"The constituent abilities, procedures, and milestones may be affected by..." How might the imposed factors impact on the abilities, procedures, or intermediate results? How should the system respond to those factors?

Figure 2. The First Two Factors of the APM (STM Segment Only)

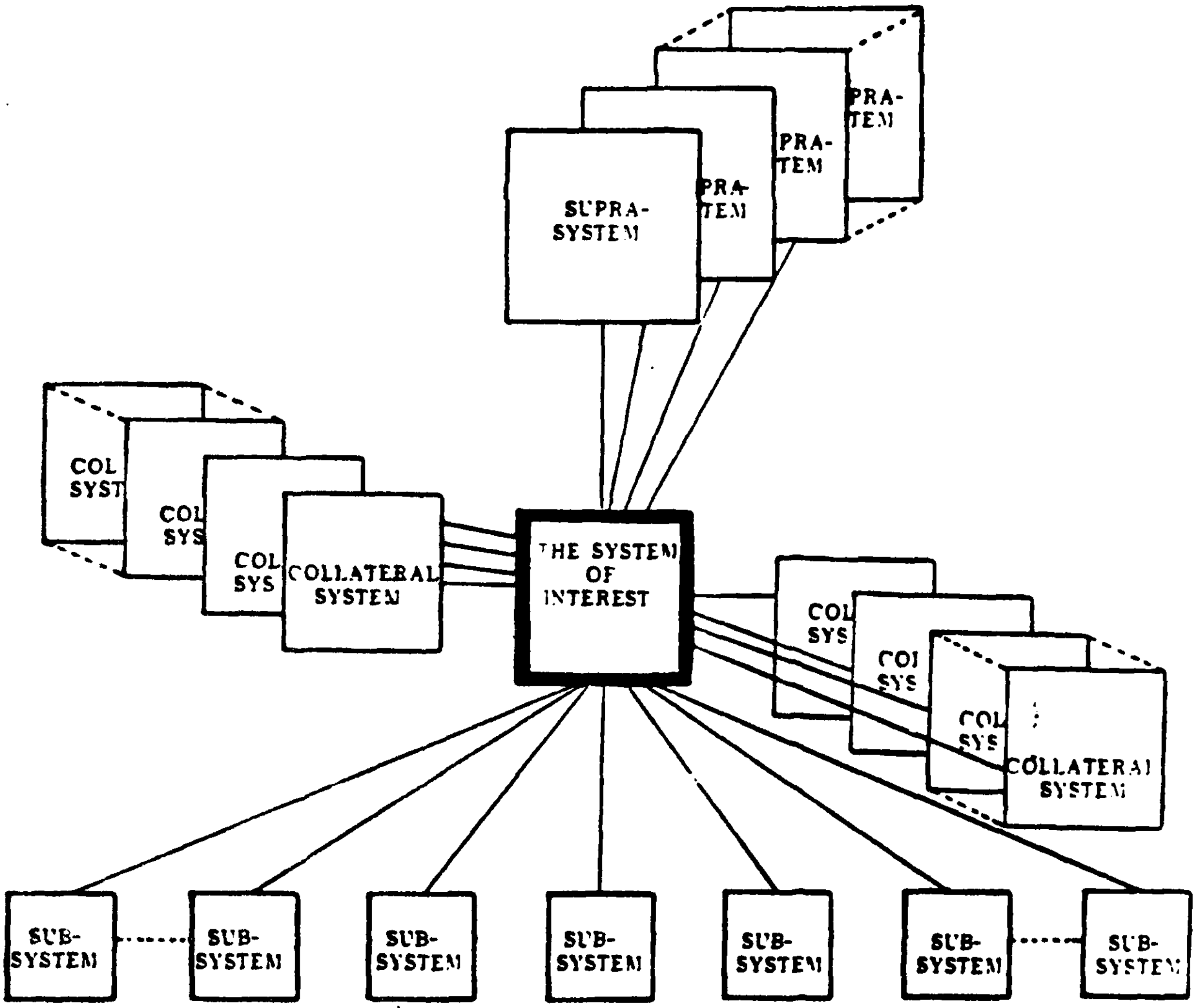

Figure 3. General Representation of a System Hierarchical Structure

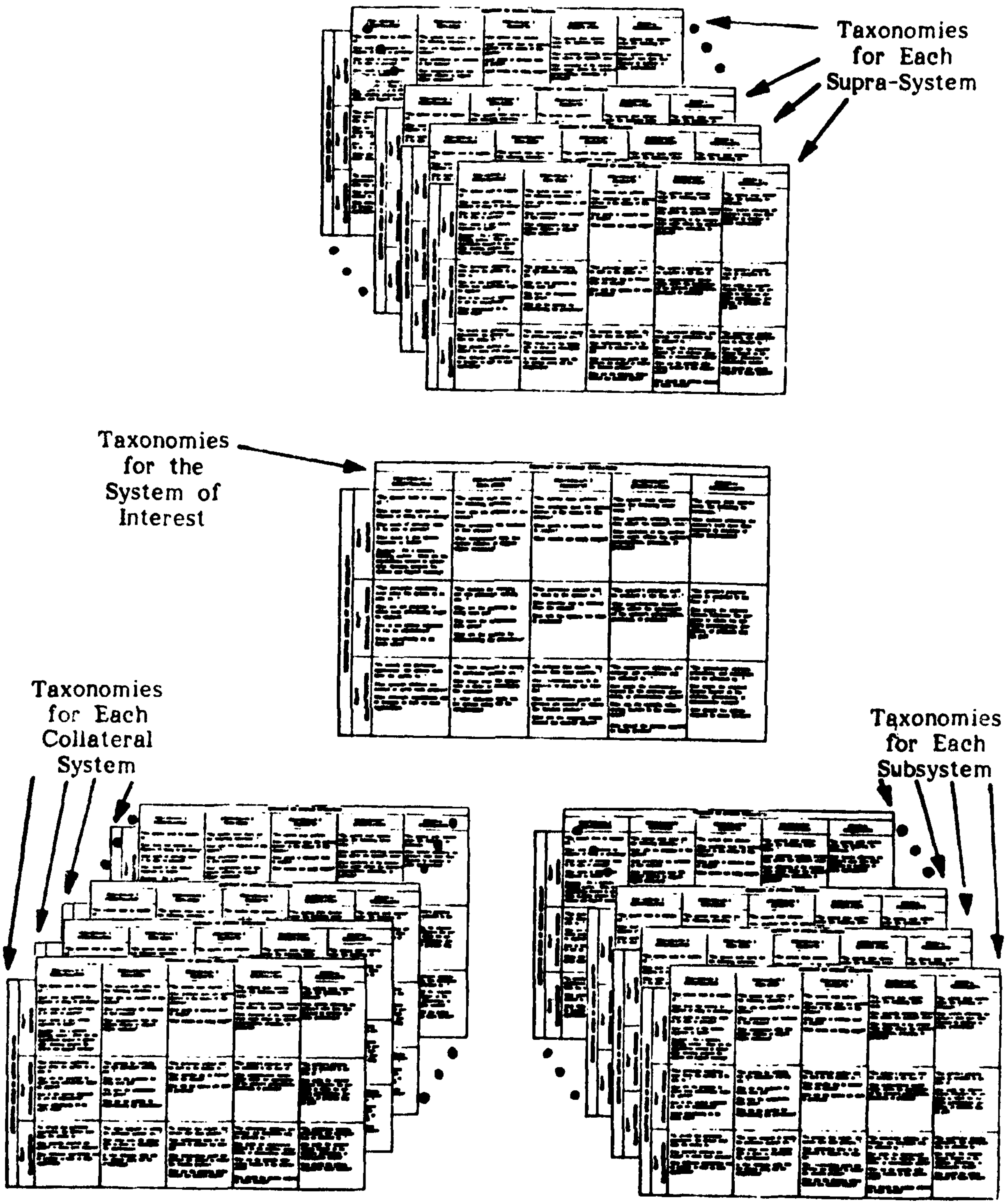

Figure 4. The Three-Factor Structure of the APM (STM Segment Only)

taxonomy of descriptors pertaining to the system being analyzed. Each item or taxon in each list is a potential basis for design specifications or evaluation measures. One can readily see the enormous magnitude of effort that could be required in applying this three-factor model even to a simple system. Hence, an increasingly important part of this study is the attempt to aid and accelerate the model application by using an interactive computer. The computer can lead the analyst through the model steps in a systematic fashion by asking the proper questions, by providing clarification and, especially, by offering the analyst general taxonomies and measures that can be used directly, ignored, modified or supplemented.

B. Model Development, Prior Applications and New Objectives

The overall goal of this project is to improve the capability for measuring the effectiveness and performance of training and other human-machine systems. However, the specific areas of emphasis within that goal have undergone redefinition and clarification during the project since 1980. In the first year, it was implicitly assumed that the research would address measurement of existing (i.e., at least prototype) systems. In this second year, however, applications to system concepts also were examined. That is, results of the first year suggested that the project's technological developments may be useful not only for evaluating emerging and operational systems, but also for helping to define and specify systems at the conceptual level, as an input to system design. Both such applications are now included within the project's scope of activities.

Also, while the project continues to seek technological developments suitable for use with the total population of human-machine systems, concentration is on training systems. It is somewhat different than the Year 1 model development effort, in which the APM was applied to the combat performance of an emerging weapon system, the Bradley Infantry Fighting Vehicle. In particular, the sample BIFV function that was most intensively analyzed with the model for measurement implications was that of Surveillance. Applications to systems of lesser complexity were also tried in Year 1, in an effort to clarify the elementary stages and procedures required of the analytic process being modeled. By the time the project began its second year, there were three major accomplishments upon which to build:

- A comprehensive analysis of the state of art of human-machine system measurement, including an annotated bibliography of literature pertaining to that field.[1]

- An improved, extended Systems Taxonomy Model, developed and verified through trial applications to systems of increasing complexity.

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[1] Edwards, J.M., Bloom, R.F., Oates, J.F., Jr., Sipitkowski, S., Brainin, P.A., Eckenrode, R.J. and Zeidler, P.C. An Annotated Bibliography of the Manned Systems Measurement Literature. Darien, CT: Dunlap and Associates, Inc., 30 November 1981.

- An outline of the overall process of human-machine system measurement, providing the skeletal structure for a total analysis process model (APM). The STM constitutes the first stage of that APM.

This second year's work was designed to continue development of the APM, proceeding from the first stage (STM) to at least the second stage (blocks 6 and 7, Figure 1) of the overall process. Previous accomplishments demonstrated that a face-valid hierarchy of measures could be derived from the taxonomies, but explicit procedures and guidelines for deriving those measures were yet to be developed. One objective of the Year 2 work was to begin developing those procedures and guidelines.

A second objective in Year 2 was to examine the applicability of the model to the definition and specification of new systems. Third, the project was to address the issue of streamlining the process of applying the STM (and APM). In particular, the potential for implementing the first portion of the APM as a computer-aided model was to be explored to a reasonable depth.

Six tasks were specified and completed for the Year 2 effort. First, the STM itself was further developed, through improvement of the taxonomization guidelines and the identification of comprehensive, usable sets of taxonomies (when possible) for the model's cells. This further development was extended to the procedures for deriving measures hierarchies once taxonomies are identified. Also addressed briefly were concepts and procedures for: (1) sorting out taxonomies and measures on a "system vs. subsystem" basis; (2) differentiating measures of "effectiveness" vs. "performance" in identified hierarchies; and (3) specifying the human contribution to any given system measure.

Second, the model was applied to one aspect of an existing system as a further test of its utility and validity for aiding systems measurement. The system of interest for that trial application was the BIFV Training System. The analytic "purpose" selected was to help measure that aspect of gunnery training design concerned with the specification of gunner-learner testing.

The third task was to apply the model to a selected system concept, to test its utility in providing input to system definition and specification. The system selected for this application was the training system for the new 9mm Army handgun. The analytic "purpose" selected was to help specify that aspect of the handgun training system concerned with the design of the curriculum.

As the fourth task, the results of the two major trial applications were examined in detail, and the needs for additional model development were identified.

The fifth task was to review the potential for implementing a computer-aided version of the extended STM. This task produced a working (but reduced-scale) computer-aided model, suitable for demonstration purposes.

The final task was to document the results of the second year's work. The principal documents produced were a working paper describing the results of the trial application to the 9mm handgun training system concept, and the present technical report providing details on all of the project's tasks. As a third item of "documentation," all products of the computer-aided implementation were delivered, including hard copy listings and magnetic disk copies of all programs and data bases (taxonomies), and equipment user manuals.

This second year's effort contributed to the longer term goals of producing:

- Automated procedures to help derive training systems effectiveness measures.
- Demonstrated applicability and usability of the APM by Army users.
- Demonstrated utility of the APM for specifying new training systems development needs.
- Guidelines and procedures for user training and user application of the automated APM.

It is envisioned that the users of the APM for design and measurement purposes will be at the U.S. Army Infantry School (USAIS) and other schools of the U.S. Army Training and Doctrine Command (TRADOC), including the Directorate of Training Development (DTD), the Directorate of Evaluation (DOE), and the Directorate of Combat Development (DCD). APM users are also foreseen to include personnel with the U.S. Army Test Boards, as well as the U.S. Army Operational Test and Evaluation Agency (USAOTEA), and, of course, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). Among the individuals at those agencies who are seen as the ultimate users of automated APM are such types as training developers and evaluators, TRADOC system managers (TSMs), system researchers and designers, analysts and planners.

The computer-aided APM will help realize the ultimate objective of providing the above-noted users with a uniform, thorough, adaptive and efficient procedure to aid in the process of deriving the most meaningful design specification requirements, design specifications, evaluation measurement requirements or evaluation measures for any planned or existing human-machine system, but particularly one in the area of training systems. Progress toward that end, as achieved in Year 2 of this contract work, is described next.

III. APPLICATIONS OF THE APM TO TRAINING SYSTEMS

The narrowed focus of the project from the total population of human-machine systems to the subpopulation of training systems, permitted considerable progress to be achieved that might not have been possible otherwise. Clear delineation of a system's hierarchical structure has been shown to be a sine qua non for the identification of performance taxa and the application of the APM. As long as the focus remained on systems-in-general, nothing specific could be said about system structure. The "general system's" hierarchy (Figure 3, earlier) is a non-specific conceptualization of suprasystems, subsystems, and collateral systems, interlinked in some undefined fashion. However, the shift of interest to one particular subpopulation immediately allowed a tractable structure to be defined in considerable detail. In other words and without extreme oversimplification, it can be said that all training systems share a common hierarchical structure, consisting of identical subsystems and analogous collateral systems and suprasystems; that these structural members can be defined in detail for purposes of APM application; and that general training system performance taxa can be identified and subsequently applied, for measurement or design specification, to any training system of interest. Identification of those general performance taxa occupied a significant segment of the research effort expended during the project's second year. Important tools now are becoming available for evaluation and design application involving this key class of human-machine systems. Those tools include a set of general performance attributes for all training systems, with computer-aided procedures for translating them into effectiveness measures or design requirements in specific training systems.

This second year of research probably would have followed a similar path and led to similar products if the focus had narrowed to any other subpopulation of systems. However, it seems particularly appropriate to have chosen training systems as the field of interest, for at least these reasons:

- Training systems are pervasive. Virtually every other kind of human-machine system requires a corresponding training system to insure its operability. Training very likely forms the largest single subpopulation of systems, and thus represents the largest potential base of applications for the APM.

- Training systems are human-focused, probably to a greater degree than is any other system subpopulation. Training system performance has an especially large component of human performance. Given ARI's fundamental focus on the behavioral and social sciences, training is an appropriate sphere of interest for this ARI research effort.

- Training is one area of human endeavor for which rapidly expanding technology is available, but only slowly or seldom is that technology

applied. Training system designers often seem to be bound by tradition and familiar practice to a greater degree than are their counterparts in other (e.g., data processing) systems. Newer, potentially more effective and less costly methods of individualized, self-paced, on-site training often seem to be overlooked in favor of the time-honored collective, group-paced, instructor-dominated academies. An analytically rigorous and performance-oriented model such as the APM should facilitate the modernization of training system design and help direct training evaluators to issues of real, current significance.

- Important new Army training systems are presently under development. Ranging from training to support use of individual weapons, through those associated with fighting vehicle operations to those linked with high level C^3 (command, control and communications) operations, these new training systems will have a major impact on the Army's overall combat effectiveness. By insuring the APM's applicability to training, this present research project may provide important assistance toward that larger issue.

Accepting, then, that training is a valid and desirable context in which to continue APM development and application, the project staff undertook the tasks of:

- Constructing a human-machine systems-oriented view of training, i.e., a view compatible with the APM's fundamental structural concepts;

- Identifying taxa of performance for key elements of a generalized training system;

- Applying those generalized taxa to emerging Army training systems, to assess their validity and their utility for system measurement and design specification;

- Investigating the feasibility of streamlining and expanding the APM's applicability to other training systems, through automation of certain procedures.

The work and results are described below.

A. Training Systems in General: Axioms for APM Application

The APM was developed for application to any human-machine system. In order to apply the model to the training sphere, it must be possible to show that a training system (as a general concept) possesses the essential characteristics of a human-machine system, and that the structure of a training system conforms to the general architecture of all systems. It is appropriate and instructive to begin by examining training in light of a general human-machine systems concept, in order to explore how that concept is reified for this particular subpopulation.

One immediately encounters a stumbling block: "human-machine system" is one of those technical/philosophical notions that, although critically important for research and scholarship, are seldom defined. The mathematical concept of a "set" is another of these. When attempts have been made to define the set concept rigorously, enlightenment and progress sometimes have resulted, but usually at the price of paradox, limitations in the utility of the concept, and disagreement among scholars holding to divergent rigorous definitions of "set." Most mathematicians accordingly prefer to deal with so-called <u>naive</u> set theory, in which no attempt is made to define the fundamental concept precisely. Instead, they adopt the implicit attitude that they "know a set when they see one," and cheerfully go about the business of achieving great breakthroughs in their research.

A human-machine system is something else that people usually feel they know when they see one. The absence of precise definitions fosters a loose and often confusing use of terms. Consider, for example, the term "subsystem." Purists (including the authors of this report) insist that, whatever else a subsystem may be, it is itself a system. That is, it must possess exactly the same essential characteristics that permit any system to be so termed. However, one often hears references to the "personnel subsystem," which has come to connote simply the people who man a system of interest, but not its equipment or other components. Further, most researchers will agree, at least in the abstract, that a "subsystem" must be totally contained within the (larger) system to which it is <u>sub</u>servient. Yet in practice one often encounters entities termed subsystems that are at least partly outside the system of interest. For example, it is common to hear speakers refer to the "maintenance subsystem" of an armored vehicle when they intend to include the personnel, equipment, and facilities at the direct support and general support levels of maintenance: components and people clearly outside the scope of the operating vehicle system itself.

It is not the intent of the authors to impose rigorous definitions upon systems theory. The purposes of this research are quite compatible with a <u>naive</u> human-machine systems science in which the entities of interest are known-when-seen. However, it is crucial that the readers of this report at least have some idea of what the authors see when they look at a human-machine system. As a fundamental axiom, the research documented herein presupposes that a human-machine system can be described (<u>not</u> defined) as:

> A collection of people, equipment, and procedures that work together to accomplish specified functions.

No attempt is made here to impose precision on the notions of people, equipment, procedures, collections, functions, or on the concept of "working together." All of these things are treated naively as things one "knows when they are seen." Nevertheless, some helpful insights can be gleaned from this naive axiom:

1. There must be at least one human in a human-machine system. Further, the humans have to take an active part in the work: they can't simply be "passengers."

2. There must be machines in a human-machine system. They too must have an active, useful role in the system's working: they can't simply be "freight."

3. There must be a purpose to a human-machine system. The humans and machines can't simply interact blindly, unconcerned about any chance results that might occur. Their functions must be specified at the outset. It may be remotely within the realm of possibility that, given enough time, ribbon and paper, a baby playing with a typewriter could reproduce the Aeneid. That would be remarkable, but there wouldn't be a human-machine system in operation unless precisely that result had been intended.

If the reader will accept this loose, axiomatic view of the world of human-machine systems, it becomes possible to ask: Does training fit this system view? What does one see when one looks at a training system? What are its purposes, or specified functions? Who are its actively working people? What is its functioning equipment? What are its procedures? How are the people, equipment and procedures organized, and how do they work together?

The authors assert as another axiom that any training system works to accomplish two fundamental purposes, or master functions: learning and helping-to-learn. These, too, are terms often defined differently by different users. In this report, the classic, broad definitions are employed:

- Learning is any activity, involving the senses, that affects behavior.

  Thus, in any training system there must be activities requiring use of a person's sight, hearing, smell, taste, feeling or any combination of senses, and those activities ultimately must impact in some intended fashion on what the person does or how the person does something.

- Helping-to-learn is simply the process of providing an efficient learning environment.

  In any training system, steps must be taken to make it as conducive as possible for the learner to learn.

Very simply, then, a training system exists if and only if somebody learns and somebody or something helps that person to learn. It might be that the person doing the learning and the person doing the helping-to-learn are the same individual and no one else is involved. It might be that many people learn simultaneously and in concert with one another, under the guidance of another individual, or with automated machinery providing the helping. It might be that many individuals interact dynamically in an atmosphere of mutual inquiry, each one learning and helping the others to learn, with no one exclusively playing the role of learning director. In any event, the people, equipment and procedures must work together to see to it that the intended learning and helping-to-learn take place.

Next, who are the people involved in a training system? In more familiar terms, who operates a training system?

It is self-evident that any training system, no matter how prosaic, must have at least one type of operator: the person or persons who do the learning. Training systems always strive to insure that human beings learn something. Helping equipment or machinery to "learn" is the province of cybernetics and programming systems. The time-honored terms for the human who learns in a training system are "student" or "trainee". However, these terms have connotations that subtly impede the marriage of training systems with modern technology. "Student" connotes a subordinate in the traditional classroom setting, for whom the principal sensory activity is listening while keeping hands still and mouth shut. "Trainee" also connotes a receptive, subservient role (where there is a "trainee," one expects to find a "trainer," and there is little doubt as to who is in charge). Further, the term "trainee" conjures up the image of a complete novice, a virtual tabula rasa. In reality, learning activities often are essential for people who already know a good deal about the subject matter of interest In an effort to remove the excess semantic baggage, the term "learne or "learners" will be used throughout this report to designate the essential training system operator or unified group of operators.

As suggested previously, it is possible for a valid training system to be operated entirely by a single individual. In that case, the learner also is the only human being responsible for helping himself or herself to learn. (Legend has it that Dizzy Dean taught himself to pitch, totally unaided. His practice consisted of hurling a homemade facsimile of a baseball at a peach basket hanging from a tree limb.) In many cases, however, other human operators are involved, even if only behind the scene. A group of learners frequently are involved together in training as a collective group, unit or team (e.g., Individual Collective Training Plan).

Who are these other operators? Since the only two functions of a training system are learning and helping-to-learn, any operators who aren't learners must be learning helpers, i.e., those who work to provide an efficient learning environment. Several subclasses of learning helpers might participate in any given training system, including:

- Training administrators. These are the people responsible for determining the basic needs for learning and for exercising command and control over the training system designed to satisfy those needs.

- Curriculum developers. These are the people who plan the sensory learning activities that will fulfill the identified needs, determine the resources of material, equipment, facilities and people needed to implement the activities, and assemble the plans and resource specifications into a workable package.

- Facilities developers. These are the people responsible for acquiring, fabricating, and/or preparing the hardware, facilities, equipment, etc., needed to implement the curriculum.

- Logistics supporters. These are the people who handle the mundane yet absolutely essential tasks incidental to training system operation, e.g., maintenance of equipment, cleaning of facilities, preparation and provision of meals, transportation, record-keeping, etc.

- Learning helpers who interact directly with the learners. About whom, more will be said shortly.

From the viewpoint of the learner, the first four classes of learning helpers listed above should be unobtrusive in the extreme. Those people should be all but invisible to the learner, their interactions with the learner kept subtle and subliminal. At its best, their work shouldn't really be noticed by the learner. Like a baseball umpire, they will be noticed only when there is some fault to find with their performance. To cite a simple example, suppose training is being conducted over a period of several days in a meeting room of a hotel isolated from other facilities. The hotel's restaurant, with its cooks, waiters, waitresses, menu, oven, wine cellar, etc., constitutes an element of the training system. Those cooks and other restaurant personnel aren't likely to think of themselves as trainers in even the broadest sense, but their work could have a significant impact on the comfort, morale, and even the physical well-being of learners and other training system operators. In short, they have something meaningful to do with the efficiency of the learning environment.

Similarly, as long as the learning needs have been identified accurately and all of the people and equipment needed to support the learning activities are present, the learner will not notice the work of the administrators or the facilities developers. As long as the specific learning objectives are relevant to the learning needs, and as long as the learning activities are well planned and inherently interesting and illuminating, the work of the curriculum developers will remain unobtrusive. It is the fate, even the aspiration, of these kinds of training system operators to be taken for granted. Their job is to do everything possible to prepare an efficient learning environment, and then to get out of the way and allow the learner to interact with that environment.

The last class of learning helpers is a case apart. Their role is one requiring direct contact with the learner. The common terms for those who play that role are very familiar and steeped in tradition: teacher, instructor, professor, trainer, etc. Here again, the connotations are not favorable to modern training technology. Each of those terms conveys the image of a classroom dominated by an authoritarian figure, actively imposing knowledge upon a group of passive recipients. The major training functions postulated above clearly demand that the learner be the principal activist in the system: it is he or she who must actually engage in the sensory activities and it is his or her behavior that ultimately is to be affected. Furthermore, much of present-day training is (or should be) tailored in pace, content, and objectives. Large classes marching in lock-step through identical learning activities toward identical goals no longer represent the optimum training modality for many applications. Thus, a better term is needed to label the

"interacting learning helpers," a term that connotes the supportive role these key operators must play and also that connotes their essential responsiveness to the needs of individual team learners. With some reluctance, the word facilitator is used in this report. It is a distastefully trendy locution, but it does at least emphasize the learning-helping nature of the operator's work and avoids the learning-dominating taint of the older expressions.

To recapitulate, the general training system model admits up to six "crew classifications," viz., the learner (the most important member of the crew); the facilitator (a key learning-helper who interacts directly with the learner); and the administrator, the curriculum developer, the facilities developer, and the logistics supporter (all of whom also are key learning-helpers, but who work generally behind the learner's scenes). It is another fundamental axiom of this research that the work done by each of these six types of system operators is required in every training system. In very large training systems, many individuals might be "assigned" exclusively to each of these "operator stations." In the smallest of all training systems, one individual might man all of the stations in a time-shared fashion. Regardless: if learning is to occur, all of their jobs must be done.

What are those jobs? Fundamentally, each operator works with other operators and with various system equipment, following prescribed procedures, to contribute to learning and helping-to-learn. Each does his or her work as the key operator of a particular training subsystem, and may play important supportive roles in other subsystems. The description and examination of those subsystems and their performance requirements occupy major portions of the remainder of this report. For the present, the kinds of tasks required of these operators can be illustrated generally as follows:

The Administrator

- Identifies needs for learning
- Establishes an overall training schedule
- Allocates resources within the system
- Recruits and selects other system operators (i.e., learners, facilitators, curriculum developers, etc.)
- Monitors progress
- Maintains records
- Evaluates operator/subsystem performance
- Evaluates system effectiveness

The Curriculum Developer

- Establishes specific learning objectives
- Determines training content
- Selects training methodologies
- Prepares/acquires plans, resources, and resource specifications
- Determines facilitator requirements
- Determines facilities requirements
- Sets learner performance standards
- Establishes specific training schedules

The Facilities Developer

- Develops/acquires training aids and devices required in the curriculum
- Develops/acquires other supporting equipment
- Develops/acquires any training sites and ranges required in the curriculum
- Adapts equipment and sites to specific learning activities

The Logistics Supporter

- Provides for ammunition, POL supplies, etc.
- Provides for transportation, feeding, lodging, recreation, etc., of all system personnel
- Provides for housekeeping, environmental control and maintenance of system equipment and facilities

The Facilitator

- Helps to motivate learners to learn
- Provides stimulation to facilitate and enhance learning
- Provides day-to-day management of learning activities
- Helps to tailor learning activities to individual and team needs
- Provides guidance to learners when needed
- Counsels learners
- Tests and critiques learners' performance

The Learner

- Carries out appropriate sensory activities to achieve intended behavioral objectives

The learner's job is most succinctly stated here, and yet encapsulates the true purpose of the whole training system. The other system operators play important roles requiring thorough preparation and much hard, dedicated work. But their work always is secondary to the learner's: a training system fails unless the learner actually learns.

Next, what is the equipment used in a training system? What machinery do the training operators operate?

Training system equipment is anything and everything (apart from the people) required for or contributing to the learning activities and the learning environment. This includes, most obviously, the equipment, machinery, tools, etc., that are used in performing the job-being-learned. One component of a handgun training system, for example, will be the handgun itself. Training system equipment also includes learning resource material, e.g, books, pictures, models, mock-ups, films, tape recording, etc., used by the learner in the conduct of the learning activities. Equipment needed to support

or apply the resource material would also be included, e.g., chalkboards, desks, tables, screens, projectors, chart stands, and so forth. Materials needed to prepare and maintain the facilities also would be part of the training system's equipment inventory, as would the facilities themselves, whether they be ranges, ditches, classrooms, bunkers, study halls or whatever. All of the equipment required to provide logistic support also would be included, e.g, kitchen supplies, sleeping accommodations, vehicles for transport, etc.

Finally, what can be said in general about the procedures used in a training system? Procedures are the specific ways in which system operators work with each other and with the various equipment in order to carry out the system's functions. Given the focus of a training system on learning and learning-helping, a training system's procedures must encompass (among many other things):

- How basic needs for learning are identified
- How learning objectives are derived from identified needs
- How learning activities are planned
- How facility requirements are determined
- How facilities are acquired or developed
- How the learners acquire information
- How the learners practice and assimilate learning
- How the environment is controlled
- How the learners are tested
- etc.

Training systems typically document some of their procedures, for example in lesson plans, schedules, etc. However, simply documenting procedures doesn't guarantee that they will be carried out as written. Learners, facilitators, and other operators often revise plans to suit their own tastes. In evaluating training system performance, it is important to assess the procedures actually used, in contrast to those officially specified.

Training, then, is an endeavor that easily lends itself to the concept of human-machine system. It always involves people, equipment and procedures working together to accomplish purposeful functions. Those functions revolve around learning, i.e., the creation of desired human behavioral effects through planned human sensory activities. All of the performance capabilities, processes, and products built into a training system must enhance or support learning. Any that do not are at best superfluous, and possibly deleterious.

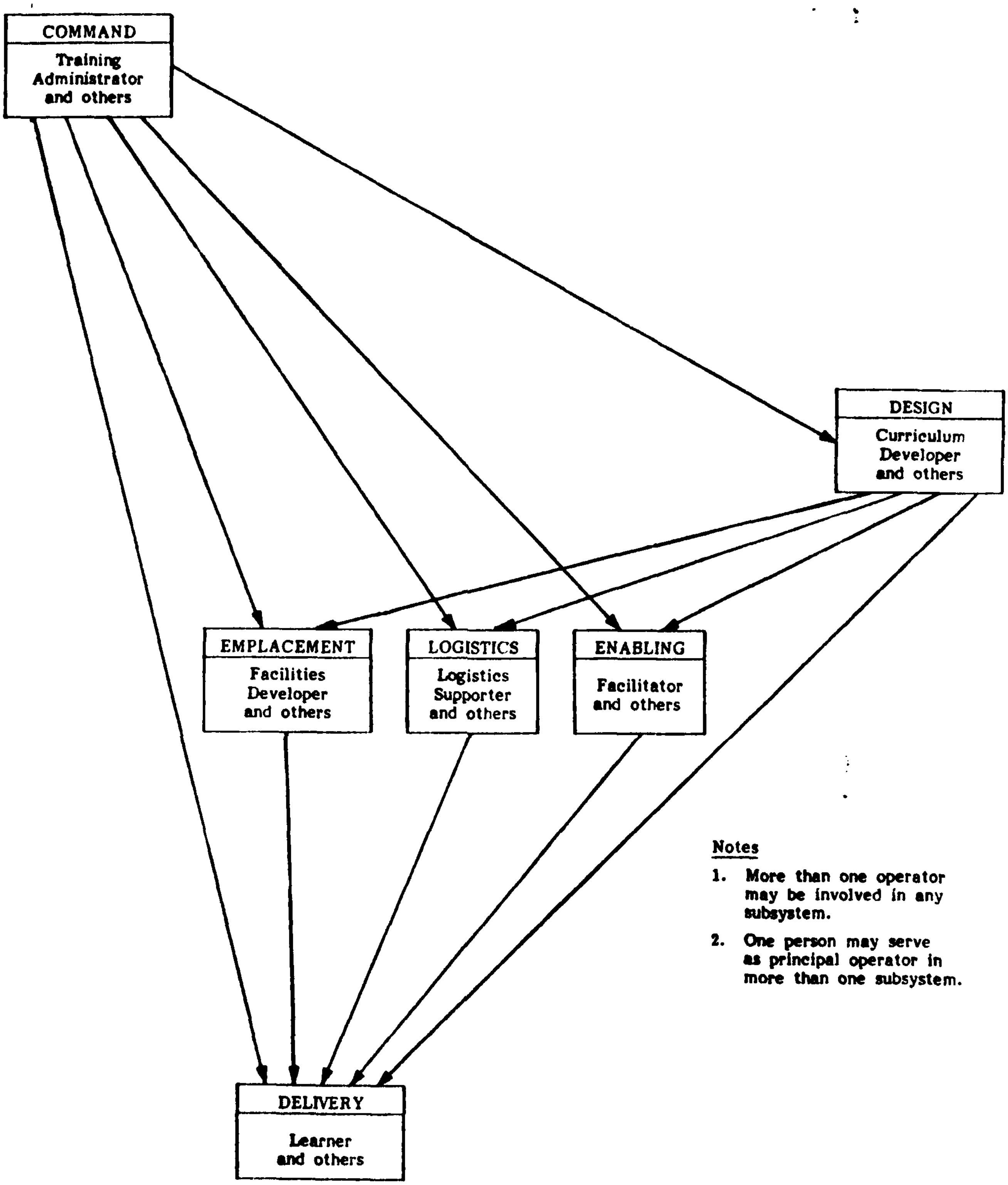
Given that training systems are indeed human-machine systems, what can be said about their <u>subsystem</u> structure? Here again, a "subsystem" is conceived to be a <u>valid system</u>, totally contained within and subservient to some larger system. The subsystem's humans and machines must all be members of the larger system, and the subsystem's purposes must be strictly supportive of the larger system's purposes.

As a final fundamental axiom, the authors assert that every training system contains six subsystems. Each subsystem constitutes the "principal territory" of one of the six training operators. The operators also play supportive roles in one another's subsystems as depicted in Figure 5. The names given to the six subsystems intentionally are non-traditional. Just as the terms learner and facilitator were adopted to avoid the undesirable connotations of "student" and "teacher," new words are needed to describe the building blocks of training in ways that do not encourage shopworn approaches to their design. Thus, for example, the term "Curriculum Development" might have been used to name the subsystem we have called "Design"; however, the older phrase carries with it the stereotypic classroom, academy, professorial image. Similarly, what we have termed "Enabling" is more commonly known as "Instructor Training." However, what unfortunately passes for instructor training all too often falls far short of the facilitator preparatory work that we perceive as essential for satisfactory system performance.

The Command subsystem is the main territory of the training administrator. The administrator, with help from others, operates the Command subsystem to exercise control over the total training system, e.g., by recruiting and selecting personnel to "staff" the other subsystems, by allocating resources to them, by evaluating their performance, etc. It is within the Command subsystem that the most fundamental decisions concerning training are made: decisions regarding what needs to be learned and who needs to learn it. Each of the other subsystems must submit its plans and products to the Command subsystem for review and approval. Command thus stands as a suprasystem for the other subsystems because of their subservience to its authority.

The principal operator of the Design subsystem is the curriculum developer. The developer, with help from others, operates the Design subsystem to translate the basic learning needs (identified by Command) into specific training plans. Design determines exactly what human behaviors are to be affected during learning, and specifies the sensory activities to be conducted to achieve the effects. In discharging that responsibility, Design makes basic decisions concerning the kinds, numbers, and qualities of facilitators, equipment, materials, and facilities needed to implement the learning activities. Design produces all of the procedures, some of the materials, and all of the resource specifications required for the Delivery subsystem (the subsystem in which learning actually takes place). Since it thus provides essential input to each of the four remaining subsystems, Design stands as a collateral system for each of them.

The Delivery subsystem is the heart of the structure. Its principal operator is the learner, who operates Delivery to implement the prescribed sensory activities and thereby acquire the intended behavioral effects. In doing so, the learner is assisted by all of the other operators, each of whom contributes in some way to the efficiency of the learning activities. Because it derives essential input from Design, Emplacement, Logistics, and Enabling, the Delivery subsystem is collateral to each of those four.



Notes

1. More than one operator may be involved in any subsystem.
2. One person may serve as principal operator in more than one subsystem.

Figure 5. Training Subsystems and Their Operators

The principal operator of the Enabling subsystem is the facilitator. This subsystem is unique in that it is itself a total training system: every Enabling subsystem plans and implements activities, involving the senses, that affect behavior in a purposeful fashion. The person engaging in those activities is the facilitator, who does so to acquire learning that will prepare him or her to work in the larger training system. The kinds of learning activities carried out in the Enabling subsystem are intended to insure that the facilitator has the basic subject matter expertise necessary to permit playing a credible and useful role in helping others to learn; has the ability to implement the kinds of interactions with learners called for in the training plans produced by the Design subsystem; and has the ability and the opportunity to tailor those plans to meet the specific learning needs of given learners. In short, the Enabling subsystem works to insure that the training plans, procedures, and resources produced by Design are made workable and viable for each Delivery application. Among many other things, activities <u>might</u> be conducted in the Enabling subsystem to insure that facilitators possess traditional platform instructional skills, but those activities would be included only if such instructional skills are relevant to the learning activities of the larger training system. Even then, instructional skill training <u>never</u> accounts for all of the work required of the Enabling subsystem.

The Emplacement subsystem is the main province of the facilities developer. This subsystem discharges the responsibility for constructing, acquiring, adapting or otherwise preparing the equipment and materials needed for the prescribed learning activities, and also for preparing the physical sites at which the activities are to take place.

The Logistics subsystem's principal operator is the logistics supporter. This subsystem carries out the work necessary to maintain the total system's humans and machines in good working order.

Having postulated that all training systems possess these six subsystems, it should be possible to point them out in the operation of any training system, large or small. This is done in the following two examples.

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EXAMPLE 1. A Small Training System

Consider first a bicycle rider training system operated by two people, a child who wishes to become a rider and a parent who agrees to help the child learn. The basic Command decision, that a need to learn to ride exists, might be initiated by the child and, after some thought, approved by the parent. The child's perceived need may be strong, motivated by envy of already-riding playmates, sharp attraction to a shiny, new bike, the desire for mobility beyond what the feet or tricycle can provide, or whatever. The parent may also perceive a need for the child to ride, based on the parent's desire to express affection, provide happiness, and aid in the overall growing process,

and also perhaps based on the parent's fond memory of having learned to ride himself or herself. However, the parent probably also assesses that need in light of other needs, such as safety, economics, etc. In any event, the decision is jointly made: if either parent or child refuses to concede the need for the child to ride, this bicycle rider training system will die aborning. Both parent and child thus are key operators of the Command subsystem, with the parent (one hopes) serving as the higher ranking operator.

If the training is to be successful, the parent had better be the sole operator of the Design subsystem. The child simply has no way of knowing, a priori, what behaviors are required for bike riding or what learning activities will lead to the mastery of those behaviors. The parent probably has a fair idea of what the behavioral objectives and learning activities ought to be, based on recollection of the parent's own bike training and on a few moments' reflection on the abilities needed for riding. Although the parent rarely will express these thoughts in classic behavioral terms, the concepts of balancing, pedaling, braking, steering, turning, signalling, etc., probably form a loose mental image of a training content outline. The painstaking or extremely motivated parent might consult a few bicycle safety and how-to-teach-your-kid-to-ride manuals. The outcome of all of this will be a very nebulous (usually) and very flexible plan for exactly what will take place when the learning actually starts. At roughly this same time the parent unconsciously should "change hats" and start to function as the operator of the Enabling system. This basically entails forming some rudimentary ideas about what will be said to the child (by way of explaining bicycle controls and operations), what will be demonstrated to the child (to clarify what is required), how the child will practice (to assimilate learning), and--very roughly--how the parent will know when the child has learned well enough to cease supervised training. The parent's work in this subsystem also extends to a "critical examination" of the child to identify any special training requirements. For example: Is the child so short that wooden blocks should be attached to the pedals? Has this child shown any special problem in balancing in the past?

Next, the parent and child move into the arena of the Emplacement subsystem. First of all, they obtain a bicycle. Although the economics of that step probably fall only on the parent, the child very likely has some input to the decision as to exactly what bike will be had. If nothing else, the choice of color might be up to the child. Training wheels might be purchased at this time. Then, a location for the training has to be chosen. Here again the parent should take charge, since the parent presumably is much better aware of the characteristics of a good practice site (traffic-free, level, paved, no obstructions, etc.) than is the child. It would be a rare parent indeed who would entertain the possibility of constructing such a site. Instead, every effort would be made to find a suitable, existing site as close to home as possible.

The parent and child operate the Logistics subsystem incidental to each training session. The parent should be responsible for handling or at least reviewing the more critical work required: seeing to it, for example, that the bike's nuts and bolts are secure, its tires properly inflated, etc. Parent and child likely will jointly inspect the practice site, finding and removing any bits of glass or other debris that could degrade safety or otherwise interfere with learning. The parent might insist that the child take responsibility for giving the bike a pre-ride cleaning.

Finally, there is the Delivery of learning. The parent explains to the child the operations required for bike riding, demonstrates these operations to clarify them in the child's mind, assists the child's first several rides by holding on to the bike to secure it, coaches the child to guide him or her toward increasingly better operation, and finally releases the bike allowing the child to practice unaided riding. From time to time, the parent will have to disentangle the fallen child from the bike, help to alleviate the physical and emotional pain created by the fall, boost the child's aspirations and resolve, and generally counsel the child through the difficult trials of the learning experience. Notwithstanding all of this parental involvement, the child clearly plays the key role in Delivery. It is the child who hears the explanations, sees the demonstrations, controls his or her muscles to move and steer the bike, contacts the ground, gets back up, dusts off and starts all over again. The child is the one living through the sensory activities. The sole determinant of the success or failure of training is the child's ultimate ability to ride.

EXAMPLE 2. A Large Training System

Next, consider briefly the training system represented by a large, private University. There can be no doubt that this is a training system, since every University (officially at least) dedicates itself to learning, implements numerous sensory learning activities, and confers certificates of learning accomplishment. Many Universities undeniably pursue other functions as well (research, football, etc.), but at its heart the essential elements of a training system are present.

The University's key Command decision, viz., the identification of learning needs, is handled by the administrative staff, typically with the advice of the faculty. Note that their true purpose in undertaking this effort is to ascertain the needs that exist in the real world beyond the University's walls. The administrators should ask themselves: What learning achievements are in demand out there, by society at large, potential employers, and potential learners? The University functions in a highly competitive, service-oriented marketplace. It may cease functioning if it fails to anticipate and cater to the learning needs perceived by the people willing to pay for that service.

The Design subsystem's principal operators are the department heads. Presumably, they take their cues from the needs identified by the administration, filtered perhaps by their appreciation of the nuances of "marketability" of the skills and knowledge available in their own disciplines. Presumably, too, they seek the advice of the members of their departments who may be a bit more in tune with the outside world than are the (typically) older and more academically entrenched chairmen. Ideally, the Design work would include interviews with real-world practitioners of each discipline, to benefit from their insights concerning the specific learning achievements that really are needed.

In universities, the Enabling subsystem usually is distributed among the individual faculty members. Their initial acceptance into the university system comes only after they have shown proof that they possess certain basic skills in their chosen fields of interest and in techniques of instruction. Usually, this "proof" is in the form of learning certificates (diplomae) awarded to them by other universities, and of endorsements by other academicians. Once accepted, they are assigned certain duties as facilitators, acquainted with the relevant curricula, and then pretty much are left on their own to get ready. Faculty members usually have considerable latitude in adapting the curricula to their own styles and tastes, in choosing the particular resource material to which the learners will be exposed, in planning the details of learning experiences, and in otherwise "fleshing out" the curricula in preparation for Delivery. A university's Design subsystem tends to produce skeletal curricula, relying on the Enabling process to add the essential substance to the structure. Thus, the same curriculum, in the hands of different faculty members, can involve significantly different learning activities and produce significantly different degrees of learning effectiveness. At least in this regard, universities tend to differ from military training systems, whose Design subsystems usually produce fairly detailed curricula and whose facilitators have considerably less leeway in modifying the curricula.

The university's Emplacement subsystem for the most part is prefabricated. It is presupposed that, whatever the learning needs and objectives might be, much the same kinds of learning activities will be conducted and much the same kind of facilities and equipment will be applicable. Universities thus expend considerable funds to provide general-purpose classrooms, libraries, laboratories, auditoria, media centers, and the like. Undeniably, this impacts on the Design and Delivery subsystems since it induces a strong pressure to use these facilities, and to shape the learning activities to conform to the available Emplacement resources. To the extent that military training systems have copied the university's predilection for expensive, fixed facilities, a predisposition against individualized, work-site training of soldiers has been created, even though work-site training might be more effective in many cases.

The university's Logistics subsystem also tends to be general-purpose. Housing, feeding, and recreation of learners, facilitators, logistics supporters,

etc., are accomplished on a mass scale, usually in that efficient but colorless style known as "institutional." Physical maintenance of facilities and equipment is similarly organized and implemented as a routinized, impersonal process.

As in any training system, it is in the university's Delivery subsystem that the learner does his or her work. To a great degree, the learner's sensory activities consist of those that are traditional in an academic setting: listening to lectures, viewing an occasional film, reading books, writing papers, participating in laboratory experiments, etc. The more fortunate learner might occasionally have an opportunity to participate in role-playing experiences, small interactive study groups, self-paced computer-assisted activities, and a generally richer environment with more active sensory experiences to enhance learning. As a subclass of training systems, however, the university may be among the slowest to adopt modern technology to its learning and learning-helping activities.

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The authors hope that these two examples have convinced the reader that the postulated six subsystems represent a reasonable and useful general model for any training system. It now remains to apply that model to construct a general representation of training system performance, and to extend that representation to particular measurement and design applications.

B. Taxonomies of Training System Performance

The authors have asserted that every training system includes subsystems that have been labeled Command, Design, Enabling, Emplacement, Logistics, and Delivery. The level of effort, the complexity, the time, the cost, and other attributes of the work carried out by those subsystems no doubt vary widely from one training system to another, as demonstrated by the examples above. But even though the amount of work needed varies, the performance requirements are stable. Each of the training subsystems exists because it makes some essential contribution to the master functions of learning and helping-to-learn. It doesn't matter whether the training system is large or small, simple or complex. The subsystem contributions are needed in every case.

What are the contributions needed from each of the six subsystems? What performance requirements must they satisfy if the total training system is to achieve its purposes of learning and helping-to-learn?

The performance requirements of each training subsystem can be identified by applying the systems taxonomization guidelines (see Figure 2) to define the taxa or categories of potentiality, process, and product which describe the subsystem and hence the populations to which it belongs. For example, one can examine training Command subsystems in general and ask:

1. What capabilities are to be provided by Command? What contribution is Command supposed to make to the abilities the system needs to accomplish learning and helping-to-learn? (Potentialities)

2. What activities are supposed to be carried out by Command? How is Command supposed to contribute to the procedures the system employs to accomplish learning and helping-to-learn? (Processes)

3. What goods or services are supposed to be produced by Command? What contribution is Command supposed to make to creating the products the system needs to accomplish learning and helping-to-learn? (Products)

These and similar questions will lead the analyst to discover the Objectives-level performance requirements of the Command subsystem, i.e., the fundamental "what" of Command performance in terms of potentialities to be possessed, processes to be undertaken, and products to be delivered.

Each Objectives-level requirement can be analyzed in greater depth, again using the taxonomization guidelines, to determine "why" it is needed. That step will disclose the Functional Purpose-level taxa to which Command belongs. These in turn can be analyzed to determine "how" the purposes are to be fulfilled, producing Command's Characteristics-level performance taxa. This same analytic approach can be taken to derive the performance taxa for Design, Emplacement, Logistics, Enabling and Delivery. Taken together, the six taxonomies will cover all of the performance requirements of the total generalized training system.

The first stages of the six taxonomies have been derived and are displayed in Figure 6. The items listed are the Objectives-level taxa, i.e., the "what" of performance requirements for each training subsystem. Those taxa could be applied to specify and/or evaluate the design of a given training system at the conceptual stage of development. In effect, the Objectives-level taxa constitute a check list for the training designer/evaluator. The designer/evaluator can review each taxon and ask, "Is this particular capability, procedure, or deliverable product relevant to my training application? If yes, has my training system concept made provision for including the capability, procedure or product? If no, how should my concept be modified to correct that deficiency?" Note, however, that the Objectives-level taxa say nothing about the particular <u>purposes</u> to which the system in question will put each capability, procedure, and product, and certainly also say nothing about the <u>design details</u> needed to insure that those

SUB-SYSTEM	POTENTIALITIES	PROCESSES	PRODUCTS
COMMAND	• PROVIDING OVERALL SYSTEM MANAGEMENT • DETERMINING LEARNING NEEDS • DETERMINING OVERALL SCOPE OF EFFORT • PROVIDING FINANCIAL RESOURCES • INSURING AVAILABILITY OF QUALIFIED STAFF AND TOOLS • MAINTAINING QUALITY CONTROL	• "MARKET ANALYSIS" OF LEARNING DEMAND • ANALYSIS OF RESOURCE REQUIREMENTS TO MEET DEMAND • COST-BENEFIT ASSESSMENT OF POTENTIAL TRAINING • RECRUITMENT, SCREENING, AND SELECTION OF PERSONNEL • SCREENING AND SELECTION OF EQUIPMENT • REVIEW AND EVALUATION OF PERFORMANCE	• SYSTEM PERSONNEL • SYSTEM MATERIEL • FUNDS • WORK ASSIGNMENTS • PERFORMANCE MILESTONES • PERFORMANCE ASSESSMENTS
DESIGN	• IDENTIFYING GOALS & PRIORITIES • ESTABLISHING PERFORMANCE OBJECTIVES • ANALYZING THE OBJECTIVES • DEFINING TRAINING CONTENT • DEFINING TRAINING PROCEDURES • EVALUATING THE CURRICULUM	• JOB ANALYSIS • ASSESSMENT OF TASKS FOR TRAINING DEVELOPMENT SELECTION • ANALYSIS OF SELECTED TASKS • ASSESSMENT OF INSTRUCTIONAL REQUIREMENTS • ANALYSIS OF EXISTING INSTRUCTION • INSTRUCTION ASSEMBLY • CONDUCT OF TRAINING TRIALS	• DOCUMENTED JOB ANALYSES • STATED PERFORMANCE OBJECTIVE • LESSON PLANS • TRAINING DOCUMENTS • TESTS • TRAINING TRIAL DATA
ENABLING	• PROVIDING DAY-TO-DAY TRAINING MANAGEMENT RESOURCES • INSURING AVAILABILITY OF INSTRUCTIONAL DELIVERY EXPERTISE • INSURING AVAILABILITY OF LEARNING GUIDANCE EXPERTISE • INSURING AVAILABILITY OF SUBJECT MATTER EXPERTISE • FAMILIARIZING FACILITATORS WITH THE CURRICULUM • TAILORING THE CURRICULUM TO SPECIFIC DELIVERY APPLICATIONS	• ANALYSIS OF FACILITATOR'S ABILITY TO PERFORM THE TASKS • ANALYSIS OF FACILITATOR'S ABILITY TO MANAGE / IMPLEMENT THE LEARNING ACTIVITIES • DESIGN ACTIVITIES TO CORRECT FACILITATOR'S DEFICIENCIES • DESIGN ACTIVITIES TO ALLOW ADAPTATION OF THE CURRICULUM • CONDUCT OF THE FACILITATOR'S LEARNING ACTIVITIES	• QUALIFIED FACILITATORS FOR GIVEN DELIVERY APPLICATIONS • CURRICULA TAILORED TO GIVEN DELIVERY APPLICATIONS
EMPLACEMENT	• INSURING AVAILABILITY OF ADEQUATE LEARNING FACILITIES • INSURING AVAILABILITY OF ADEQUATE LEARNING MATERIALS • INSURING AVAILABILITY OF ADEQUATE INSTRUCTIONAL AIDS	• ANALYSIS OF CURRICULUM TO DETERMINE EMPLACEMENT REQUIREMENTS • ACQUISITION, CONSTRUCTION AND/OR MODIFICATION OF LEARNING FACILITIES • ACQUISITION, CONSTRUCTION AND/OR MODIFICATION OF LEARNING MATERIAL • ACQUISITION, CONSTRUCTION AND/OR MODIFICATION OF INSTRUCTIONAL AIDS	• APPROPRIATE LEARNING FACILITIES FOR GIVEN DELIVERY APPLICATIONS • APPROPRIATE LEARNING MATERIAL FOR GIVEN DELIVERY APPLICATIONS • APPROPRIATE INSTRUCTIONAL AIDS FOR GIVEN DELIVERY APPLICATIONS
LOGISTICS	• INSURING AVAILABILITY OF ADEQUATE PERSONNEL SUPPORT • INSURING AVAILABILITY OF ADEQUATE FACILITIES MAINTENANCE • INSURING AVAILABILITY OF ADEQUATE EQUIPMENT MAINTENANCE	• ANALYSIS OF DELIVERY PLANS TO DETERMINE LOGISTICS REQUIREMENTS • DEVELOPMENT OF SCHEDULE OF PERSONNEL SUPPORT SERVICES • DEVELOPMENT OF SCHEDULE OF PREVENTIVE MAINTENANCE SERVICES • DEVELOPMENT OF PROCEDURES FOR RESTORATIVE MAINTENANCE • ACQUISITION OF FACILITIES AND MATERIALS NEEDED FOR DELIVERY OF THE SERVICES • DELIVERANCE OF THE SERVICES	• PERSONNEL SUPPORT SERVICES • FACILITIES MAINTENANCE SERVICE • EQUIPMENT MAINTENANCE SERVICE
DELIVERY	• PROVIDING LEARNERS WITH THE LEARNING ENVIRONMENT • INSURING LEARNERS' INTERACTION WITH THE ENVIRONMENT • MANAGING LEARNERS PROGRESS • EVALUATING LEARNERS' ACHIEVEMENT • PROVIDING BASES FOR SYSTEM EVALUATION	• ANALYSIS OF SPECIFIC LEARNER'S NEEDS • CONDUCT PREPARATION LEARNING ACTIVITIES • CONDUCT PRESENTATION / DEMO. LEARNING ACTIVITIES • CONDUCT APPLICATION / PRACTICE • CONDUCT LEARNER TESTING • ACQUISITION OF FORMATIVE EVALUATION DATA	• APPROPRIATE LEARNING ACTIVITIE • LEARNERS WHO HAVE ACHIEVED THE STATED OBJECTIVES • ASSESSMENT OF LEARNERS ACHIEVEMENTS • FORMATIVE EVALUATION DATA

Figure 6. Objectives-Level Performance Taxa of Training Subsystems

purposes will be accomplished. That is, the "what" of performance says nothing about the "why" or "how" of performance. Taxa must be identified on the functional purposes- and characteristics-levels in order to obtain inputs relevant to "why" and "how" issues concerning design and evaluation.

To date, taxonomies complete on all three levels have been compiled for the Design and Enabling subsystems. These two were singled out to initiate training system taxonomization for two reasons. First, they are the most extensively studied and best documented of the training subsystems. Procedural manuals and research reports abound that deal with both civilian and military applications of instructional system Design and Enabling (the latter, typically under the title "Instructor Training"). Representative documents from that literature base were reviewed in depth in preparation for the present work, which then proceeded in a less speculative atmosphere than might have been the case if other subsystems had been selected. It might be added, in this same context, that the authors' have substantial prior experience in training systems Design and Enabling applications.

The second major reason for addressing these two subsystems is that they are probably of greatest concern to training systems at early stages of development. Two important, emerging Army training systems are at such stages, namely, the Bradley Infantry Fighting Vehicle Training System (BIFVTS) and the new 9 mm handgun training system. The developers of those systems conceivably could benefit from a specification of Design and Enabling performance requirements. Figures 7 and 8, respectively, present complete taxonomies for the Design and Enabling training subsystems.

The taxa contained in Figures 7 and 8 represent the basic building blocks for both design and evaluation of the two training subsystems. Each taxon is a performance-oriented design requirement. The subsystem designer examines a particular taxon and asks, "How can I best insure that this requirement will be satisfied by the subsystem I am building?" The evaluator looks independently at the same taxon and asks, "How can I tell whether this particular subsystem satisfies that requirement?" Answers to the designer's question produce system specifications. Answers to the evaluator's question lead to measures of system performance/effectiveness.

A decimal indexing code was established to facilitate the categorization of all three levels of system description. Each contextual aspect was assigned a unique number, as follows:

1.0 Performance Potentialities
2.0 Performance Processes
3.0 Performance Products
~~Etc.~~

At the Objectives Level, the population categories ~~is~~ are assigned successive numbers in the first decimal position. For example, ~~at the Objectives Level,~~

	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
OBJECTIVES	1.1 Identifying goals and priorities 1.2 Establishing performance objectives 1.3 Analyzing performance objectives 1.4 Defining training content 1.5 Defining training procedures 1.6 Evaluating the curriculum	2.1 Analyze the job for which training is to be developed 2.2 Assess tasks for training development 2.3 Analyze tasks selected for training 2.4 Determine instructional requirements 2.5 Analyze existing instruction 2.6 Assemble instruction 2.7 Conduct training trials	3.1 Documented job analyses 3.2 Stated performance objectives 3.3 Lesson plans 3.4 Training documents 3.5 Tests 3.6 Training trial data
FUNCTIONAL PURPOSES	1.1.1 Defining the total scope of learning 1.1.2 Stating the ultimate intended outcomes of learning 1.1.3 Identifying the relative importance of intended outcomes 1.1.4 Establishing a basis for specifying learning objectives 1.2.1 Stating what the learners will be able to do or how they will be expected to behave after training 1.2.2 Providing a basis for objectively assessing learner performance 1.3.1 Identifying prerequisites to learning 1.3.2 Providing a basis for objectively assessing a candidate learner's suitability 1.3.3 Identifying interactions/dependence among objectives 1.3.4 Classifying objectives in terms of domains of learning 1.3.5 Identifying component steps or processes within the objectives 1.4.1 Selecting stimuli for each objective 1.4.2 Selecting instructional setting for each objective 1.4.3 Defining instructional sequence 1.5.1 Specifying preparation procedures 1.5.2 Specifying presentation procedures 1.5.3 Specifying application procedures 1.5.4 Specifying (learner) evaluation procedures 1.6.1 Validating/revising the bases for the developing curriculum 1.6.2 Validating/revising the developing curriculum itself	2.1.1 Identify the tasks that are involved in the job 2.1.2 Determine the sequence and stimuli of the tasks 2.1.3 Determine the level of skill or performance deemed adequate for the job 2.2.1 Determine needs for training as a function of task 2.2.2 Allocate training development and delivery resources 2.3.1 Identify the information processing entailed in the task 2.3.2 Classify the tasks in terms of the domains of learning involved 2.3.3 Identify the conditions for learning the task 2.4.1 Identify instructional events/activities required 2.4.2 Identify strategic instructional requirements 2.4.3 Identify tactical instructional requirements 2.4.4 Identify learner assessment requirements 2.5.1 Assess relevance and applicability of existing instruction to present requirements 2.5.2 Assess effectiveness/efficiency of existing instruction in light of state-of-art methods/media 2.6.1 Adapt relevant and applicable instruction, where possible, to satisfy present instructional requirements 2.6.2 Create instruction, where necessary, to meet unsatisfied instructional requirements 2.7.1 Guide the ongoing analysis and assembly of instruction 2.7.2 Verify the suitability of the assembled instruction for delivery	3.1.1 Provide a complete specification of what constitutes the job to be trained 3.1.2 Provide a complete specification of the organization of the job 3.1.3 Provide a complete specification of what constitutes job adequacy 3.2.1 Define exactly what the learners are expected to achieve as a result of the training 3.2.2 Provide an organizational framework for the training 3.3.1 Provide complete specification of the instructional content for each objective 3.3.2 Provide complete specification of the instructional procedures for each objective 3.3.3 Provide complete specification of the instructional circumstances for each objective 3.4.1 Provide essential resources to learners 3.4.2 Provide essential guidance to facilitators 3.4.3 Provide essential specifications to facilities developers 3.4.4 Provide essential support to training system administrators 3.5.1 Acquire qualified candidate learners 3.5.2 Tailor instruction to learners 3.5.3 Measure learner's achievements 3.6.1 Provide justification for specific features of instructional design 3.6.2 Demonstrate validity and utility of the training

Figure 7. Taxonomy of Design Subsystem Performance

CHARACTERISTICS

PERFORMANCE POTENTIALITIES

1.1.1.1	Identifying types of achievements relevant to the intended job
1.1.1.2	Analyzing achievements to determine suitability for training
1.1.2.1	Determining necessary levels of achievement
1.1.2.2	Determing existing levels of achievement
1.1.2.3	Discerning discrepancies between existing and necessary levels
1.1.3.1	Assessing goal importance
1.1.3.2	Insuring availability of a relative (numeric) goal ranking scheme
1.1.4.1	Insuring availability of a hierarchy/taxonomy of objectives
1.1.4.2	Stating goals in terms that imply behaviors
1.2.1.1	Defining the performance action
1.2.1.2	Defining the performance conditions
1.2.1.3	Defining the performance standard
1.2.2.1	Developing pretest items
1.2.2.2	Developing posttest items
1.3.1.1	Revealing present conditions of learning (i.e., that which learners must recall)
1.3.1.2	Identifying essential prerequisites (capabilities incorporated within the objective)
1.3.1.3	Identifying supportive prerequisites (capabilities facilitating achievement of objectives)
1.3.2.1	Developing entry test items
1.3.3.1	Discerning independence between objectives
1.3.3.2	Discerning dependency between objectives
1.3.3.3	Discerning supportive relationship between objectives
1.3.4.1	Identifying information type objectives
1.3.4.2	Identifying mental skills type objectives

PERFORMANCE PROCESSES

2.1.1.1	Review job specification/description
2.1.1.2	Interview job/system designers
2.1.1.3	Observe job incumbents
2.1.1.4	Interview job incumbents
2.1.1.5	Prepare tentative task list
2.1.1.6	Authenticate tenative task list using representative job designers/incumbents
2.1.1.7	Validate task list using other representatives
2.1.2.1	Review job specification/description
2.1.2.2	Interview job/system designers
2.1.2.3	Observe job incumbents
2.1.2.4	Interview job incumbents
2.1.2.5	Prepare tentative task flowchart
2.1.2.6	Prepare tentative task stimuli specifications
2.1.2.7	Authenticate tentative flowchart and stimuli specifications using representative job designers/incumbents
2.1.2.8	Validate flowchart and stimuli specifications using other representatives
2.1.3.1	Review job specification/description
2.1.3.2	Interview job/system designers
2.1.3.3	Interview job supervisors/commanders
2.1.3.4	Observe/interview "high"-rated incumbents
2.1.3.5	Observe/interview "low"-rated incumbents
2.1.3.6	Prepare tentative skill/performance specifications
2.1.3.7	Authenticate performance specifications using representative designers/supervisors/incumbents
2.1.3.8	Validate performance specifications using other representatives
2.2.1.1	Develop training needs criteria in concert with representative system users/designers
2.2.1.2	Rate tasks in accordance with the specified criteria
2.2.2.1	Determine degree of learning difficulty for each task requiring training
2.2.2.2	Determine degree of instruction needed for each such task

PERFORMANCE PRODUCTS

3.1.1.1	Specification of mental processes to the level of binary decisions
3.1.1.2	Specification of physical processes to be level of discrete actions
3.1.1.3	Specification of all process stimuli
3.1.1.4	Specification of conditions under which processes are to take place
3.1.2.1	Operational sequence diagrams
3.1.2.2	Decision flowcharts
3.1.2.3	Specification of rules and regulations
3.1.3.1	Performance accuracy specification
3.1.3.2	Performance speed specification
3.1.3.3	Performance volume specification
3.1.3.4	Performance duration specification
3.2.1.1	Specification of the basic capabilities the learners are to acquire
3.2.1.2	Specification of an observable action the learners will execute to demonstrate each capability
3.2.1.3	Specification of a measurable object that will result from the action
3.2.1.4	Specification of the circumstances under which the learners will execute the action
3.2.1.5	Specification of any tools or equipment the learners will use to execute the action
3.2.1.6	Specification of any constraints imposed upon the learners' execution of the action
3.2.1.7	Specification of the criteria the resulting object must satisfy in order to demonstrate acceptable achievement of the basic capability
3.2.2.1	Specification of the essential abilities included within each performance objective
3.2.2.2	Specification of the supportive abilities to be included in instruction for each objective

Figure 7 (Continued

CHARACTERISTICS (Cont'd)

PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
1.3.4.3 Identifying physical skills type objectives	2.3.1.1 Analyze the decision flow to reduce processing to a sequence of binary decisions	3.2.2.3 Specification of the sequence of instruction in essential and supportive abilities to be prepared for each objective
1.3.4.4 Identifying attitude type objectives	2.3.1.2 Analyze the decision levels in terms of nature, complexity, and time	3.2.2.4 Specification of the sequence of objectives to be following in the instruction
1.3.5.1 Identifying overt steps	2.3.2.1 Identify knowledge to be acquired	3.3.1.1 Specification of the objective
1.3.5.2 Identifying covert steps	2.3.2.2 Identify mental skills to be acquired	3.3.1.2 Specification of assumed learner prerequisites
1.3.5.3 Identifying unconscious steps	2.3.2.3 Identify physical skills to be acquired	3.3.1.3 Itemization of information topics
1.4.1.1 Defining propositions, names, facts, etc., relevant to information objectives	2.3.2.4 Identify attitudes to be acquired	3.3.1.4 Itemization of mental skills steps
1.4.1.2 Defining concepts, rules, algorithms, etc., relevant to mental skills objectives	2.3.3.1 Analyze information processing requirements to identify prerequisite knowledge expected of learners	3.3.1.5 Itemization of physical skills steps
1.4.1.3 Defining movements, timings, actions, etc., relevant to physical skills objectives	2.3.3.2 Analyze those requirements to identify prerequisite mental skills	3.3.1.6 Itemization of attitudinal components
1.4.1.4 Defining values, choices, etc., relevant to attitudinal objectives	2.3.3.3 Analyze the physical requirements to identify prerequisite motor skills	3.3.1.7 Itemization of practice exercises
1.4.2.1 Assessing applicability of Job Performance Aids (JPAs)	2.3.3.4 Analyze the attitudinal requirements to identify prerequisite values	3.3.1.8 Itemization of test problems/exercises
1.4.2.2 Assessing applicability of Self-Teaching Exportable Packages (STEPs)	2.4.1.1 Select the types of events/activities required to prepare learners to learn the various tasks	3.3.2.1 Specification of procedures for preparing learners to achieve the objective
1.4.2.3 Assessing applicability of Formal on-the-Job Training (FOJT)	2.4.1.2 Select the types of events/activities required to present/demonstrate the tasks	3.3.2.2 Specification of how the instructional content topics/steps will be presented
1.4.2.4 Assessing applicability of Installation Support School (ISS)	2.4.1.3 Select the types of events/activities required for learners to practice/apply the tasks	3.3.2.3 Specification of how the learners will practice/apply the instructional content
1.4.2.5 Assessing applicability of Resident School (RS)	2.4.1.4 Select the types of events/activities required to evaluate learners' performance	3.3.2.4 Specification of how the learners will be tested on the instructional content
1.4.3.1 Sequencing in dependency order	2.4.2.1 Analyze events/activities to establish their sequence	3.3.2.5 Specification of procedures for dealing with learners who fail to demonstrate achievement of the objective
1.4.3.2 Sequencing in supportive relationship (efficiency) order	2.4.2.2 Analyze events/activities to establish their delivery media	3.3.3.1 Specification of the location at which each instructional event will take place
1.5.1.1 Defining facilitator preparation activities	2.4.3.1 Analyze events/activities to establish their management procedures	3.3.3.2 Specification of the equipment needed
1.5.1.2 Defining facilities preparation requirements	2.4.3.2 Analyze events/activities to establish their resource requirements	3.3.3.3 Specification of special location/equipment set-up/configuration requirements
1.5.1.3 Defining attention-gaining procedures	2.4.4.1 Analyze tasks to identify assessment requirements for selecting/accepting learners	3.3.3.4 Specification of instructional personnel needed
1.5.1.4 Defining objective-informing procedures		3.3.3.5 Specification of time and schedule requirements
1.5.1.5 Defining procedures for stimulating learners' recall of prerequisites		3.4.1.1 Texts
1.5.2.1 Defining presentation media/media alternatives		3.4.1.2 Workbooks
1.5.2.2 Defining procedures and requirements for placing emphasis		3.4.1.3 Study guides
1.5.2.3 Defining procedures for enhancing learners' comprehension and retention		3.4.1.4 Lists of references
		3.4.1.5 Schedule of instruction

Figure 7 (Continued)

	PERFORMANCE POTENTIALITIES		PERFORMANCE PROCESSES		PERFORMANCE PRODUCTS	
CHARACTERISTICS (Cont'd)	1.5.3.1	Defining procedures for enhancing learners' involvement/participation	2.4.4.2	Analyze tasks to identify assessment requirements for providing remedial instruction	3.4.2.1	Sets of lesson plans
	1.5.3.2	Defining procedures for eliciting performance from learners	2.4.4.3	Analyze tasks to identify assessment requirements for accelerating/tailoring learners' progress through the instruction	3.4.2.2	Sets of test specifications
	1.5.3.3	Defining procedures for providing learning guidance to learners	2.4.4.4	Analyze tasks to identify assessment requirements for advancing/delaying learners' progress through the instruction	3.4.2.3	Lists of facilitator references
	1.5.3.4	Defining procedures for providing learning feedback to learners	2.4.4.5	Analyze tasks to identify assessment requirements for certifying/decertifying learners as job performers	3.4.2.4	Specifications of facilitator prerequisites
	1.5.3.5	Defining procedures for assessing sufficiency of practice	2.5.1.1	Specify criteria of relevance and applicability	3.4.3.1	Specifications of physical requirements for instructional sites
	1.5.4.1	Defining procedures to assess the proper domains of learning	2.5.1.2	Search for existing instruction of potential relevance and applicability	3.4.3.2	Specifications for audiovisuals
	1.5.4.2	Defining procedures to assess the appropriate action/behavior	2.5.1.3	Access and review existing instruction deemed to be of potential relevance and applicability	3.4.3.3	Specifications for training equipment and supplies
	1.5.4.3	Defining procedures to insure assessment reliability	2.5.1.4	Rate relevance/applicability of instruction	3.4.4.1	Detailed outline of instructional objectives, content, procedures, and schedule
	1.6.1.1	Entry-level testing of representative candidate learners	2.5.1.5	Select existing instruction warranting application to present instructional requirements	3.4.4.2	Specifications of learner prerequisites
	1.6.1.2	Post-training testing of representative job incumbents	2.5.2.1	Identify instructional events/activities implemented by technologically outmoded methods/media	3.4.4.3	Summaries of personnel requirements
	1.6.2.1	Obtaining error data	2.5.2.2	Assess degree of inefficiency/ineffectiveness	3.4.4.4	Summaries of facilities requirements
	1.6.2.2	Obtaining design feedback	2.5.2.3	Assess cost of replacing outmoded instruction	3.4.4.5	Documentation of all activities during the process
	1.6.2.3	Correlating post-test data with subsequent job performance	2.5.2.4	Formulate decision to use or replace existing instruction	3.5.1.1	Measures of prerequisite abilities
			2.6.1.1	Identify specific deficiencies in the events/activities of the applicable instruction	3.5.1.2	Measures application procedures
			2.6.1.2	Develop specific changes to the events/activities and their prescriptions to remove the deficiencies	3.5.1.3	Standards of candidate qualification
			2.6.2.1	Identify specific objectives for which new instruction is needed	3.5.1.4	Specifications for dealing with substandard candidates
			2.6.2.2	Analyze the objectives to identify the instructional events/activities needed	3.5.2.1	Pre-training measures of intended abilities
			2.6.2.3	Select implementing methods/media	3.5.2.2	Measures application procedures
			2.6.2.4	Prepare detailed prescriptions of the methods and media	3.5.2.3	Standards of pre-training qualification
					3.5.2.4	Specification of procedures for dealing with qualified learners
					3.5.3.1	Post-training measures of intended abilities
					3.5.3.2	Measures application procedures
					3.5.3.3	Standards of post-training qualification
					3.5.3.4	Specification of procedures for dealing with unqualified learners
					3.6.1.1	Entry test data derived from representative candidate learners

Figure 7 (Continued)

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	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
CHARACTERISTICS (Cont'd)		2.7.1.1 Apply small blocks of existing instruction to individual candidate learners 2.7.1.2 Apply small blocks of new instruction to individual candidate learners 2.7.1.3 Apply small blocks of assembled instruction to small groups of candidate learners	3.6.1.2 Post-test data derived from representative job incumbents 3.6.1.3 Test item error analyses derived from tryout learners 3.6.1.4 Instruction design feedback data obtained from tryout learners and facilitators 3.6.1.5 Specification of revisions based on these data
		2.7.2.1 Conduct field testing of the assembled instruction	3.6.2.1 Test item error analyses derived from field test learners 3.6.2.2 Correlations between learners' post-test results and subsequent job performance 3.6.2.3 Instruction design feedback data obtained from field test learners and facilitators 3.6.2.4 Specification of final revisions based on these data

Figure 7 (Concluded)

	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
OBJECTIVES	1.1 Providing day-to-day training management resources 1.2 Insuring availability of instructional delivery expertise 1.3 Insuring availability of learning guidance expertise 1.4 Insuring availability of subject matter expertise 1.5 Familiarizing facilitators with the curriculum 1.6 Tailoring the curriculum to specific delivery applications	2.1 Analyze facilitator's ability to perform the tasks 2.2 Analyze facilitator's ability to manage/implement the learning activities 2.3 Design activities to correct facilitator's deficiencies 2.4 Design activities to allow adaptation of the curriculum 2.5 Conduct the facilitator's learning activities	3.1 Qualified facilitators for given delivery applications 3.2 Curricula tailored to given delivery applications
FUNCTIONAL PURPOSES	1.1.1 Establishing a schedule of learning activities 1.1.2 Establishing a conducive learning climate 1.1.3 Monitoring and modifying the learning experience 1.1.4 Operating the training facilities and equipment 1.1.5 Implementing learning activities 1.1.6 Acquiring and disseminating learning resources 1.2.1 Conveying learning stimuli 1.2.2 Presenting information 1.2.3 Demonstrating procedures 1.2.4 Conducting learner practice 1.2.5 Conducting learner tests 1.3.1 Motivating learners to learn 1.3.2 Focusing learners' attention and interest 1.3.3 Relating the learning to the learners' experience 1.3.4 Coaching learners 1.3.5 Feeding-back to learners 1.3.6 Facilitating learner self-assessment 1.3.7 Counseling learners 1.4.1 Knowing the ingredients of that which is to be learned 1.4.2 Performing/demonstrating that which is to be learned 1.4.3 Citing illustrative examples to assist learning	2.1.1 Identify tasks for which a given prospect could credibly serve as a facilitator 2.1.2 Identify task performance deficiencies for a given prospect which could be corrected through cost-effective training 2.2.1 Identify learning activities which a given prospect could credibly manage/implement 2.2.2 Identify deficiencies in learning activity management/implementation for a given prospect which could be corrected through cost-effective training 2.3.1 Devise plans to insure that each facilitator achieves requisite levels of job performance skills 2.3.2 Devise plans to insure that each facilitator achieves requisite levels of instructional skills 2.4.1 Devise plans to insure that each facilitator learns the curriculum and its instructional requirements 2.4.2 Devise plans to insure that each facilitator learns the particular requirements of a given delivery application 2.4.3 Devise plans to insure that each facilitator develops the additional details of procedure and materials needed for a given delivery application	3.1.1 Facilitators able to help create a rich learning environment for the learners 3.1.2 Facilitators able to guide learners' interactions with the environment 3.2.1 Curricula relevant to the learning needs of given learners 3.2.2 Curricula geared toward the experiences of given learners

Figure 8. Taxonomy of Enabling Subsystem Performance

	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
FUNCTIONAL PURPOSES (Cont'd)	1.5.1 Knowing what learners are intended to achieve 1.5.2 Knowing the training content 1.5.3 Knowing the training resources 1.5.4 Knowing the training procedures and methods 1.5.5 Knowing the training circumstances 1.6.1 Adapting the curriculum to the facilitator's style and strengths 1.6.2 Adapting the curriculum to the specific learning needs of a given delivery application 1.6.3 Adapting the curriculum to specific constraints of a given delivery application	2.5.1 Facilitators demonstrate satisfactory levels of job performance skills 2.5.2 Facilitators demonstrate satisfactory levels of instructional skills 2.5.3 Facilitators demonstrate satisfactory abilities to implement the curriculum for a given delivery application	
CHARACTERISTICS	1.1.1.1 Identifying scheduling options 1.1.1.2 Devising schedule monitoring mechanisms 1.1.1.3 Devising schedule control mechanisms 1.1.2.1 Encouraging maximum learner participation 1.1.2.2 Eliciting sense of responsibility for learning from learners 1.1.2.3 Treating learners with respect 1.1.2.4 Encouraging learners' freedom of expression 1.1.2.5 Avoiding disorder and learner distaste 1.1.3.1 Measuring learners' progress 1.1.3.2 Diagnosing emerging deficiencies and difficulties in learning 1.1.3.3 Simplifying key operative information 1.1.3.4 Tailoring learning activities to specific experiences of learners 1.1.3.5 Tailoring schedule and sequence of learning to learners' capabilities and needs 1.1.4.1 Developing skills in the use of relevant instructional aids	2.1.1.1 Assess prospect's experiential history with respect to the tasks 2.1.1.2 Assess prospect's training with respect to the tasks 2.1.1.3 Assess degree to which the prospect manifests the qualities and characteristics of a good performer of the tasks 2.1.2.1 Test the prospect's ability to satisfy the performance objectives associated with each task 2.1.2.2 Estimate the cost of training that would be necessary to achieve satisfaction of the performance objectives 2.1.2.3 Formulate decisions to provide or not provide task performance training for each prospect on each task 2.2.1.1 Assess prospect's experiential history with respect to managing/implementing those types of learning activities 2.2.1.2 Assess prospect's prior training relative to those types of learning activities	3.1.1.1 Facilitators knowledgeable of the ingredients of the learning objectives 3.1.1.2 Role-model performers of the ingredients 3.1.1.3 Facilitators knowledgeable of the activities that can support achievement of the learning objectives 3.1.1.4 Insurers of the adequacy of the physical learning environment 3.1.1.5 Insurers of the availability of needed materials and resources 3.1.1.6 Communicators of interest and enthusiasm for the learning 3.1.1.7 Facilitators who are respectful of learners 3.1.1.8 Facilitators who are accepting of learners' needs and differences 3.1.1.9 Facilitators who are supportive and encouraging of learners' initiatives 3.1.1.10 Facilitators who are accessible to learners 3.1.2.1 Elicitors of learners' participation in the learning planning process

Figure 8 (Continued)

CHARACTERISTICS (Cont'd)

PERFORMANCE POTENTIALITIES		PERFORMANCE PROCESSES		PERFORMANCE PRODUCTS	
1.1.4.2	Developing skills in the appropriate control of the physical environment	2.2.1.3	Assess degree to which prospect manifests the qualities and characteristics associated with a good manager/implementer of those types of learning activities	3.1.2.2	Creators of conditions to enhance desire for learning
1.1.4.3	Developing skills in the preparation of relevant special facilities and equipment	2.2.2.1	Test the prospect's ability to manage/implement the learning activity in question	3.1.2.3	Diagnosticians of learning needs
1.1.5.1	Preparing learners to learn	2.2.2.2	Estimate the cost of training that would be needed to prepare the prospect to manage/implement each activity	3.1.2.4	Creators of experience to enhance learning
1.1.5.2	Presenting learning content to learners	2.2.2.3	Formulate decisions to provide or not provide facilitator training for each prospect on each learning activity	3.1.2.5	Counselors of learners
1.1.5.3	Guiding learners' application of learning	2.3.1.1	Identify specific performance objectives for which job performance training is needed	3.1.2.6	Boosters of learners' aspirations and efforts
1.1.5.3	Testing learners' achievement of learning	2.3.1.2	Analyze the objectives to identify the learning events/activities needed	3.1.2.7	Managers of media to aid the learning process
1.1.6.1	Assembling learning-relevant experiences	2.3.1.3	Select implementing methods/media	3.1.2.8	Deliverers of information
1.1.6.2	Acquiring and/or fabricating resource materials	2.3.1.4	Prepare/assemble detailed prescriptions of the methods and media	3.1.2.9	Coaches of learners
1.2.1.1	Informing learners of the learning objectives	2.3.2.1	Identify specific performance objectives for which facilitator training is needed	3.1.2.10	Evaluators of learners' progress
1.2.1.2	Relating objectives to learners' own needs	2.3.2.2	Analyze the objectives to identify the learning events/activities needed	3.2.1.1	Performance objectives specifications couched in terms relevant to the given learners' needs
1.2.1.3	Relating objectives to learners' own experiences	2.3.2.3	Select implementing methods/media	3.2.1.2	Plans for learning activities/experiences that are in accordance with the given learners' needs
1.2.2.1	Gearing presentations to learners' abilities and achievements	2.3.2.4	Prepare/assemble detailed prescriptions of the methods and media	3.2.1.3	Presentations, applications, and tests that are consistent with the given learners' intended applications of learning
1.2.2.2	Selecting meaningful images, patterns, etc., to vivify content	2.4.1.1	Identify specific performance objectives relating to familiarity with the curriculum and instructional requirements	3.2.1.4	Complete sets of refinements and details necessary to implement the curriculum in a fashion consistent with learners' needs
1.2.2.3	Utilizing multiple senses to reinforce learning	2.4.1.2	Analyze the objectives to identify the learning events/activities needed	3.2.2.1	Performance prerequisite specifications couched in terms relevant to the given learners' experiences
1.2.2.4	Involving learners actively in the presentation	2.4.1.3	Select implementing methods/media	3.2.2.2	Plans for learning activities/experiences that draw upon the given learners' experiences
1.2.3.1	Exposing each step in the procedure	2.4.1.4	Prepare/assemble detailed prescriptions of the methods and media	3.2.2.3	Presentations and applications that make use of the given learners' experiences
1.2.3.2	Clarifying the purpose for each step	2.4.2.1	Identify specific performance objectives relating to familiarity with the requirements of a given delivery application		
1.2.3.3	Manifesting performance technique				
1.2.3.4	Involving learners actively in the demonstration				
1.2.4.1	Selecting and creating opportunities for practice				
1.2.4.2	Involving learners actively in practice				
1.2.4.3	Sequencing practice experiences to enhance learning development				

Figure 8 (Continued)

	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
CHARACTERISTICS (Cont'd)	1.2.4.4 Developing and maintaining realism in practice 1.2.4.5 Observing and tutoring learners in practice 1.2.4.6 Helping learners sense progress toward learning objectives and goals 1.2.5.1 Diagnosing specific needs for learning 1.2.5.2 Diagnosing learners' progress 1.2.5.3 Diagnosing deficiencies in the learning environment 1.3.1.1 Clarifying the value of the learning to the learners 1.3.1.2 Demonstrating enthusiasm 1.3.1.3 Encouraging learners' aspirations and initiatives 1.3.1.4 Rewarding learners' progress and participation 1.3.1.5 Demonstrating patience and compassion 1.3.2.1 Creating situations and learning activities that are inherently interesting 1.3.2.2 Conveying a sense of excitement 1.3.2.3 Dramatizing for emphasis and reinforcement 1.3.2.4 Sensing and responding to learners' attention and interest 1.3.3.1 Exploiting learners' experiences through discussions, case studies, role-playing, etc. 1.3.3.2 Emphasizing immediacy of application of learning to learner-relevant problems/needs 1.3.4.1 Raising and maintaining learners' level of aspiration for achievement 1.3.4.2 Mediating and facilitating the transfer from training to operations	2.4.2.2 Analyze the objectives to identify the learning events/activities needed 2.4.2.3 Select implementing methods/media 2.4.2.4 Prepare/assemble detailed prescriptions of the methods and media 2.4.3.1 Identify specific performance objectives relating to developing additional details 2.4.3.2 Analyze the objectives to identify the learning events/activities needed 2.4.3.3 Select implementing methods/media 2.4.3.4 Prepare/assemble detailed prescriptions of the methods and media 2.5.1.1 Implement activities to prepare facilitators to achieve the needed job performance skills 2.5.1.2 Implement activities to present/demonstrate the skills to facilitators 2.5.1.3 Implement activities to insure that facilitators practice the skills 2.5.1.4 Implement activities to test the facilitators' achievement of the needed job performance skills 2.5.2.1 Implement activities to prepare facilitators to achieve the needed learning facilitation skills 2.5.2.2 Implement activities to present/demonstrate the skills to the facilitators 2.5.2.3 Implement activities to insure that facilitators practice the skills 2.5.2.4 Implement activities to test facilitators' achievement of the needed learning facilitation skills 2.5.3.1 Implement activities to prepare facilitators to achieve the needed curriculum implementation abilities 2.5.3.2 Implement activities to present/demonstrate the abilities to the facilitators	

Figure 8 (Continued)

	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
CHARACTERISTICS (Cont'd)	1.3.4.3 Serving as a mentor to extend and control learners' talent	2.5.3.3 Implement activities to insure that facilitators apply the curriculum implementation abilities	
	1.3.4.4 Prompting and cuing learners, when necessary	2.5.3.4 Implement activities to test the facilitators' curriculum implementation abilities and application products	
	1.3.5.1 Conveying diagnoses of learners' performance to learners		
	1.3.5.2 Positively reinforcing desirable performance		
	1.3.5.3 Constructively criticizing deficient performance		
	1.3.6.1 Assisting learners to develop and apply self-evaluation procedures suited to learning objectives		
	1.3.6.2 Assisting learners to diagnose their own needs for learning		
	1.3.6.3 Assisting learners to translate diagnosed needs into specific objectives and learning activities		
	1.3.7.1 Assisting learners to plan and organize their learning activities		
	1.3.7.2 Assisting learners to implement their learning activities		
	1.3.7.3 Assisting learners in dealing with problems affecting their learning progress/achievement		
	1.3.7.4 Interacting with learners to bolster morale and raise aspirations as learners' motivation and efforts diminish		
	1.4.1.1 Knowing the elements of the cognitive (factual) aspects of the training		
	1.4.1.2 Knowing the elements of the psychomotor (skill) aspects of the training		
	1.4.1.3 Knowing the elements of the affective (attitudinal) aspects of the training		
	1.4.2.1 Demonstrating and articulating the cognitive tasks of the job		
	1.4.2.2 Demonstrating and articulating the psychomotor tasks of the job		

Figure 8 (Continued)

	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
CHARACTERISTICS (Cont'd)	1.4.2.3 Demonstrating and articulating the attitudes required of the job 1.4.3.1 Relating practical applications of the intended learning by role-model performers 1.4.3.2 Relating beneficial learning experiences used by previous learners 1.4.3.3 Facilitating interchange of relevant experiences of current learners 1.5.1.1 Understanding the intended goals of learning 1.5.1.2 Understanding the intended performance objectives 1.5.1.3 Understanding the prerequisite abilities expected of learners 1.5.2.1 Understanding the topics to be covered 1.5.2.2 Understanding the associations among topics and performance objectives 1.5.2.3 Understanding the organization of the content's topical sequence 1.5.3.1 Understanding the personnel resources available and needed 1.5.3.2 Understanding the equipment resources available and needed 1.5.3.3 Understanding the material/media resources available and needed 1.5.3.4 Understanding the facilities resources available and needed 1.5.4.1 Understanding the preparation activities and procedures to be used 1.5.4.2 Understanding the presentation activities and procedures to be used 1.5.4.3 Understanding the application activities and procedures to be used 1.5.4.4 Understanding the evaluation activities and procedures to be used		

Figure 8 (Continued)

	PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS
CHARACTERISTICS (Cont'd)	1.5.5.1 Understanding what conditions are to be controlled during learning activities		
	1.5.5.2 Understanding how to control those conditions		
	1.6.1.1 Capitalizing on facilitators' own experiences that are relevant to the intended learning		
	1.6.1.2 Selecting learning activity options that are compatible with facilitators' own instructional skills		
	1.6.1.3 Developing procedural details to enhance facilitators' delivery of instruction		
	1.6.1.4 Acquiring and/or refining materials to enhance facilitators' delivery of instruction		
	1.6.2.1 Deleting performance objectives that are not relevant to the learning needs of a given delivery application		
	1.6.2.2 Defining new performance objectives relevant to the learning needs of a given delivery application		
	1.6.2.3 Modifying content to reflect changed objectives		
	1.6.2.4 Modifying resources to reflect changed objectives		
	1.6.2.5 Modifying procedures and methods to reflect changed objectives		
	1.6.2.6 Modifying conditions to reflect changed objectives		
	1.6.3.1 Modifying resources to reflect specific constraints		
	1.6.3.2 Modifying procedures and methods to reflect specific constraints		
	1.6.3.3 Modifying conditions to reflect specific constraints		

Figure 8 (Continued)

under Performance Potentialitites, each population category is identified as 1.1, 1.2, 1.3, etc. The Functional Purposes Level descriptions is assigned a two decimal code, i.e., 1.1.1, 1.1.2, 1.1.3, etc. Finally, the Characteristics Level of system description is assigned a three decimal code, i.e., 1.1.1.1, 1.1.1.2, 1.1.1.3, etc. The decimal numbering of the population categories simply aids in organizing the population categories in such a way so that the analyst can easily trace the subpopulation categories of Objectives Level, Functional Purposes Level and Characteristics Level populations.

Subsequent segments of this report illustrate the application of these taxa to produce measures and design specifications for representative military training systems. To prepare for those sample applications, this segment closes with brief clarifications of the design and measurement implications of one taxonomic subset of the Design subsystem. This clarification also will serve to elucidate certain of the terms and concepts of a general training system.

Sample Taxonomic Subset

Training Subsystem:	Design
Performance Category:	1.0 Performance Potentialities
Objectives-level taxon:	"1.2 Establishing Performance Objectives"

Derivative Functional Purposes-level taxa:

"1.2.1 Stating what the learners will be able to do or how they will be expected to behave after completing training"

"1.2.2 Providing a basis for objectively assessing learner performance"

Derivative Characteristics-level taxa:

"1.2.1.1 Defining the performance action"	"1.2.2.1 Developing pretest items"
"1.2.1.2 Defining the performance condition"	"1.2.2.2 Developing posttest items"
"1.2.1.3 Defining the performance standard"	

One of the many fundamental capabilities that the Design subsystem is expected to provide for the benefit of the total training system is the ability to establish performance objectives for learning. The Command subsystem

decrees that learning will take place, having identified a "job" for which training is needed. However, Command defines the "job" only in broad terms, e.g., "we need to train soldiers to man the Bradley Infantry Fighting Vehicle." It is up to Design to translate that broad statement into a behavioral reference framework that is compatible with learning. Given that learning is sensory activity intended to affect behavior, one of the Design subsystem's first responsibilities is to establish exactly what behaviors are to be affected, and exactly how they are to be affected. In training system terms, that is called "establishing performance objectives."

Performance objectives are simply behaviors, expected of the learner upon completion of training, that can be defined and observed in quantifiable terms. Precise definition of observable behavior is absolutely essential, both to determine the training content and methods and to evaluate training effectiveness. A training designer would never (or should never) say something like "one of my objectives is to give the BIFV gunner trainees an appreciation of the kinds of targets they can engage with the weapons on this vehicle." There is nothing quantifiable or directly observable about "appreciation." What does a learner have to do to acquire an "appreciation"? How can one tell whether one learner has achieved more "appreciation" than another? Of course, what the designer really means is that the gunner-learners should come to know what targets can and should be engaged by each type of weapon. That is a better statement of the training purpose, but it still isn't expressed in behavioral terms. A true performance objective expressing what the designer really intends might be stated as follows: "Given a list of the types of targets to be engaged, the learner will state the appropriate weapon/ammunition to be used to engage each target." The intended behavior is a series of audible statements of weapon/ammunition type, which is readily quantifiable as to the accuracy of each statement.

In the absence of valid performance objectives, no one really knows what the intended behavioral outcome of the training is supposed to be, and so no one can properly design or evaluate the sensory activities that are to form the training experience. Thus, both the designer and the evaluator of any training system must concern themselves with the issue of the Design subsystem's ability to establish performance objectives. At the top-most level of design and evaluation, crucial questions such as the following must be asked:

- Is there a person (or persons) assigned to the Design subsystem who has the knowledge and skills needed to establish valid performance objectives for training?
- Do the plans submitted by Design subsystem for Command's review and approval call for the establishment of performance objectives?
- Do those plans allocate appropriate manpower and other resources to the establishment of performance objectives?

- Do the plans provide for obtaining the input information necessary for the establishment of performance objectives?

Once the designer and evaluator are satisfied (from their different perspectives) that the basic capability of "establishing performance objectives" has been provided in the Design subsystem, their attention shifts to ascertaining how and whether this capability can satisfy its functional purposes. The Design subsystem is expected to be able to establish performance objectives for two reasons: first, so that it will be possible to state what the learners will be able to do or how they will behave subsequent to training; second, so that it will be possible to develop an objective basis for assessing learner performance in training. At this level of detail, the designer and evaluator deal with such issues as:

- Does the basic capability for establishing performance objectives lend itself to specifying learners' terminal behaviors?

- Do the plans and procedures used by the Design subsystem call for specifying learners' terminal behaviors?

- Is the basic capability for establishing performance objectives actually being applied to prepare for learner performance assessment?

Finally, the designer and evaluator shift their focus to the technical details necessary to apply the capability of establishing performance objectives to achieve the two functional purposes. Numerous issues come to their attention at this stage, including the following:

- Does the Design subsystem's capability for establishing performance objectives extend to the specification of the actions that the learners are to perform? Does the capability for specifying the actions insure that the actions are observable and quantifiable? Does it insure that the actions specified accurately demonstrate the intended behaviors?

- Does the capability for establishing performance objectives extend to the specification of the conditions under which the learners are to perform the actions? Does it insure that the conditions specified are relevant to actual job requirements?

- Does the capability for establishing performance objectives extend to the specification of standards of acceptable performance? Does it insure that the standards specified are appropriate and relevant to actual job requirements?

- Does the Design subsystem possess the capability of developing means of testing learners' performance prior to training? Does that capability insure that the test items reflect the specified performance objectives? Do Design subsystem plans call for establishing and applying such pretest items?

- Does the Design subsystem possess the capability of developing means of testing learners' performance after or at completion of training? Does that capability insure that the test items reflect the specified performance objectives? Do Design subsystem plans call for establishing and applying such posttest items?

Training system designers and training system evaluators work with the very same system performance requirements. The designer's genius lies within his or her ability to select the approaches, methods, and means for insuring that the requirements are satisfied by the system being built. The evaluator's genius is found in his or her selection of the approaches, methods, and means of determining how well the designer's job was done. After they have both completed their work, the evaluator is required to "report back" his or her findings so that the designer may correct any deficiencies that may have been uncovered. With respect to the Design subsystem performance requirements surrounding the potentiality of "establishing performance objectives," the evaluator could submit any of the following "reports" to the designer:

Possible Report No. 1:

> "Look, you never saw to it that your Design subsystem included a capability for establishing performance objectives. None of the people that you assigned to the subsystem had any knowledge of what constitutes a valid, useful performance objective, and none of them had any experience in conducting the kinds of front-end analyses needed to identify appropriate objectives. The result was that the so-called job and task analyses that they performed were badly botched and are just about useless, and their so-called training objectives don't deserve the name. The Design subsystem has failed to specify what the learners are supposed to be able to do. That means there is no way of telling whether the curriculum's content, schedule, sequence, or procedures are any good at all."

Possible Report No. 2:

> "Okay, you provided the basic capability for establishing performance objectives when you assigned John Jones and Mary Smith to that task. They have solid credentials in that area; they're good analysts, and you gave them sufficient resources to get the job done. They produced what appears to be a very good set of statements concerning the learners' intended achievements: the actions, conditions, and performance standards are well described and based on very thorough job analyses. The problem is, you didn't see to it that their excellent work would be applied to assessing learner's performance. The people you assigned to the task of developing test items seem never to have even considered the performance objectives, and certainly never consulted John or Mary. At least half of the stated performance actions aren't elicited by any

of the test items, either pre- or post-. Almost all of the actions that are elicited are called for under conditions that aren't even close to those specified in the performance objectives. The net result is that you won't be able to tell whether your learners have actually achieved their intended learning."

Possible Report No. 3:

"John's and Mary's assignment to the Design subsystem provided a solid capability for establishing performance objectives, and you were wise to task them also with the assignment of preparing pre- and post-test items to address each objective. They're good, hard, skillful workers, and they produced excellent statements of the performance actions and conditions required of the learners, and some very well constructed test items. The only problem is that you didn't give them quite the support they needed. Mary tells me that she and John just didn't have enough time and funds to do a proper analysis of the job performance standards. She admits that some of the criteria they state in their performance objectives are largely wild guesses. I'd suggest that you scrape up some more funds to allow them to study the jobs and tasks to greater depth, so that we can be sure that the performance standards reflect what really is required in the field. Otherwise, we might find that we are either undertraining or overtraining our learners, and we might be giving them tests that are either too easy or too hard."

Possible Report No. 4:

"You did a fine job in seeing to it that the basic capability for establishing performance objectives was built into the Design subsystem. In choosing Mary and John to operate that subsystem, you obtained the services of two of the best in the business. They tell me that you saw to it that they received all of the resources and support they needed to do the job the right way. It's clear that your system had everything needed to produce comprehensive, well stated, and complete performance objectives, and to reflect the objectives in the test items that were developed. There is absolutely no fault to find with this element of your system's performance."

These are not all of the possible reports that an evaluator might submit concerning a Design subsystem's potential for establishing performance objectives, but they do span the full range of possible findings. In the first report, the evaluator finds that a basic required potentiality simply is absent from the system being studied: this particular system has no capability for establishing performance objectives. This is a failure detected at the objectives level of design/measurement. A fundamental element of the "what" of performance is unsatisfied. Note, too, that the failure is diagnosed as a missing potentiality. The evaluator does comment on the fact that there are process failures ("badly botched job and task analyses") and product failures

("stated performance objectives that don't deserve the name"), but it is clear that the evaluator perceives these to be the natural results of the more fundamental potentiality failure ("none of the people had any knowledge of or experience with establishment of performance objectives"). At this stage the evaluator is focusing on a taxon of potentiality. In h[illegible]r her complete report, detailed comments presumably also would be made on the related process and product taxa, i.e., the evaluator would document exactly how the job and task analysis processes were "botched" and exactly how the stated performance objectives products were deficient.

In Report No. 2, the evaluator finds a different situation. Here, there is evidence that the essential requirements for establishing performance objectives were met. Qualified people were brought to the assignment, and they were given the tools needed to do the job of producing the objectives. Indeed, the evaluator finds that they did produce the objectives. However, their capabilities and their products were not applied to the task of providing a basis for assessing learner performance. This is a failure on the functional purposes level of design/measurement, a deficiency in the "why" of this system's performance. A key potentiality was made available in the system, but the system failed to apply that potentiality properly.

The evaluator finds still a different situation in the third report. The system has the basic (objectives level) potential for establishing performance objectives. The system applies that potentiality to achieve its two intended (functional) purposes. However, detailed analysis discloses that the potentiality breaks down at the characteristics level of design/measurement, i.e., in the "how" of performance. The potentiality for establishing performance objectives is deficient in one characteristic, namely, the ability to specify standards of performance. The evaluator traces this to an insufficiency in the resources provided for applying the capability, which probably is a typical reason for a malfunction on the characteristics level.

At this point it is apprropiate to reflect on the hierarchical relationship that binds the objectives, functional purposes, and characteristics levels of system design/measurement. It is clear that a system performance failure on the objectives level automatically implies corresponding failures on the functional purposes and characteristics levels. Very simply, if a system does not possess some essential potentiality, or does not carry out some essential process, or does not deliver some essential product, there is no way that the system can then apply that potentiality, process, or product to serve its intended purposes: you can't use what you don't have. Also, the absence of the potentiality, process, or product itself certainly implies the absence of all of its characteristics that are required for any intended purpose. However, the mere fact that the system satisfies its objectives-level performance requirements does not guarantee that the associated functional purposes and characteristics requirements will be met. The system might have all of its basic potentialities, carry out all of its basic processes, and produce all of its basic products, but fail to apply them for the required purposes. Further, those basic potentialities, processes, and products may not have exactly the right characteristics needed to satisfy those purposes.

In the evaluator's fourth report, a happy finding is documented. The system under study has everything necessary to insure that the potentiality of establishing performance objectives is present in all of its characteristic details, and will be applied to serve its intended purposes. The evaluator commends the designer on this particular element of his or her work.

But what exactly is the evaluator saying in that excerpt? The statement only says that a requirement for potential performance has been met. The evaluator has worded the statement in a way that carefully avoids saying anything about the processes carried out or the products delivered. Potentiality does not guarantee achievement. Any person, no matter how capable, can make mistakes. Any machine can break down. In the context of the simple example we have been using, it is possible that John Jones and Mary Smith could "botch up" a job analysis in spite of all their experience. The system designer and the evaluator cannot be satisfied with seeing to it that the system has the potential to do its job. They also have to see to it that the proper processes are planned and implemented and that the proper products are specified and actually delivered.

This brings us to the point where it is appropriate to reflect on the hierarchical relationship involving the three aspects of system performance, viz., potentialities, processes, and products. Their relationship is similar to that involving the three levels of system description. The absence of some required potentiality will give rise to corresponding breakdowns in the system's processes and products. If a basic capability is missing, the process used to apply that capability cannot be carried out successfully. If the process cannot be carried out, the fruits of the process (i.e., some product) will not be delivered as needed. On the other hand, the potentiality might be there but the processes using that potentiality might nevertheless go awry. A process might be carried out without fault, but the resulting product might nevertheless be deficient. The expression "garbage in, garbage out" familiar to data processors refers to this situation: the data processing might be fine but the output products might be worthless, because the inputs also were of no value. Thus, just as each level of system description must be designed and evaluated in turn, so must each aspect of performance. The system designer and the system evaluator should always proceed from general to specific, from the basic to the detailed, from the potential to the actual, to insure that all appropriate steps are taken to bring about a system that does exactly what it is supposed to do. Figure 9 illustrates this essential developmental flow within the general systems taxonomy structure. The basic flow for either design or measurement applications is from the most fundamental requirements of potentiality to the most detailed requirements of product, always insuring that all intermediate processes and purposes receive careful attention. Sample applications of this concept are given in the segments that follow.

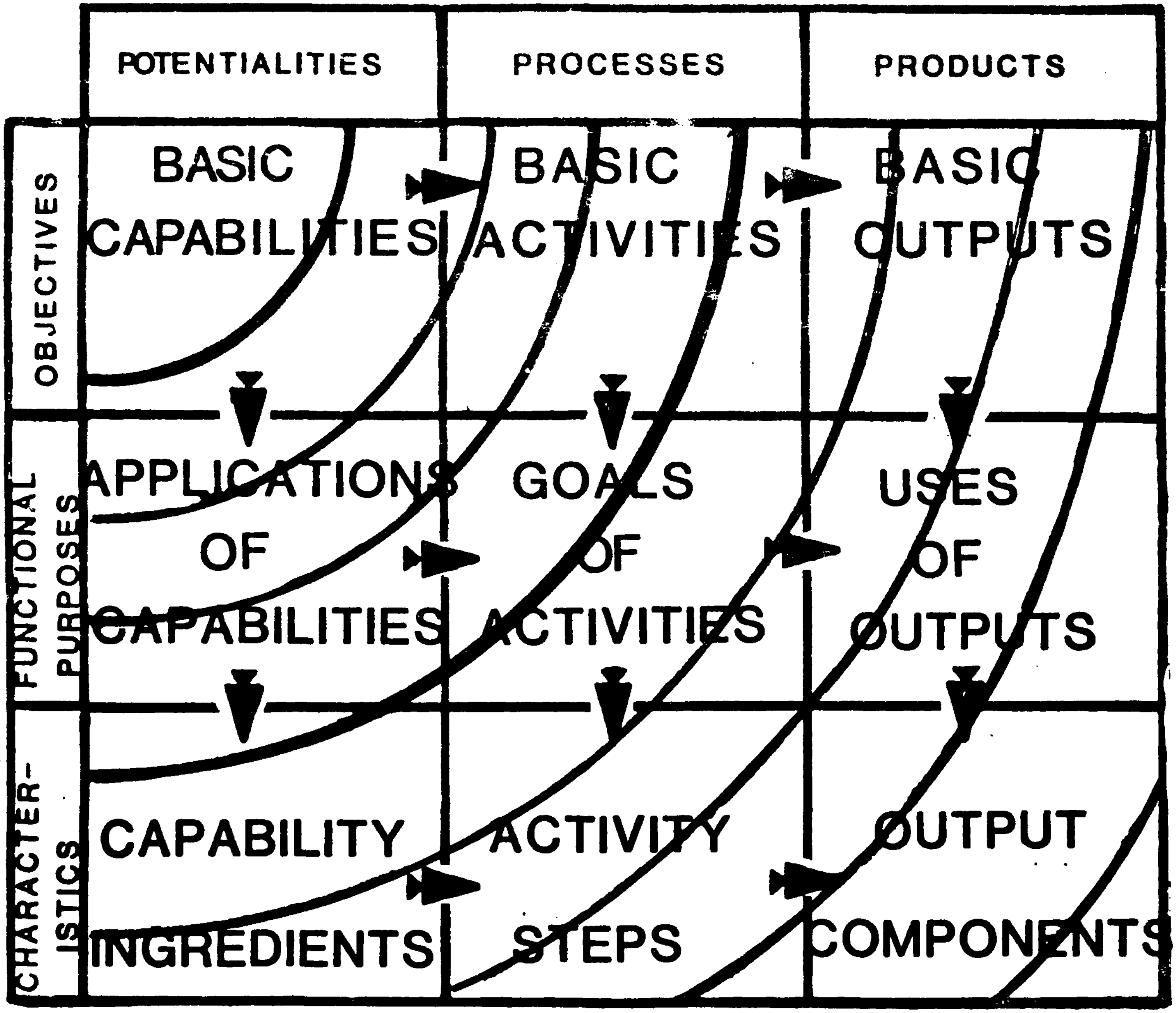


Figure 9. APM Application Flow

C. The APM for Measurement of Training System Performance/Effectiveness

The purpose of this segment is to illustrate how the performance taxa identified for any particular human-machine system can be applied to derive useful measures of that system's performance/effectiveness. The approach taken proceeds through the following steps:

(1) Define precisely the system of interest.
(In this example, the system of interest will be one subsystem of one portion of an emerging Army training system.)

(2) Define precisely the measurement application.
(Here, the application will focus on one aspect of the training system's planned learning activities.)

(3) Identify the particular performance taxa that are relevant to that measurement application.
(Not all of a system's performance requirements are of interest to every measurement application. This example will illustrate the procedures to be used to determine which requirements are relevant and which are not.)

(4) Establish the issues and implications for measurement that derive from each relevant taxon.
(The derivative issues and implications clarify exactly what relevance the particular performance requirement has for the measurement application at hand.)

(5) Posit measures that will address each issue and implications.
(Here, the measures will be workable means of determining whether the training system satisfies its relevant performance requirements in a way that insures the adequacy of the particular learning activities being examined.)

1. The System of Interest: The Design Subsystem of BIFV Gunnery Training

The U.S. Army Infantry School presently is developing a training system that will be employed to supply qualified operators for the new Bradley Infantry Fighting Vehicle (BIFV). This new Bradley Infantry Fighting Vehicle Training System (BIFVTS) will prepare soldiers and officers for assignments as BIFV squad members (skill level 1 soldiers); BIFV drivers; BIFV gunners; BIFV Commanders; and various support functions on various levels of command (platoon, company, etc.). Figure 10 depicts the network of other systems that interact with BIFVTS. These include:

- The system known as the U.S. Army Infantry School. At its present stage of evolution, BIFVTS is wholly contained within the Infantry School, which therefore is a BIFVTS suprasystem. As will be shown below, the school presently operates the BIFVTS Command and Design subsystems.

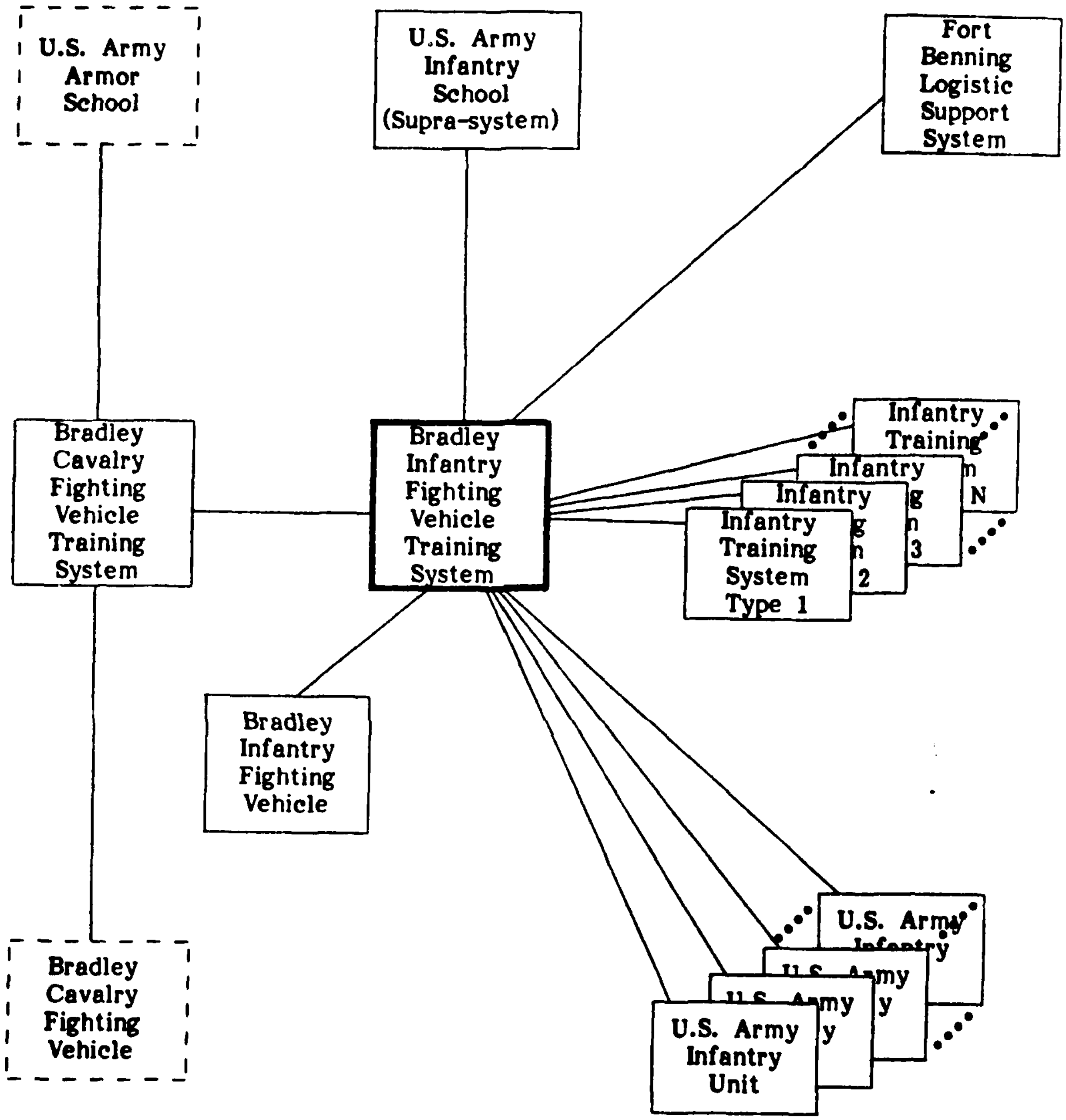


Figure 10. Major Systems Interacting with BIFVTS

- Various existing and possibly emerging infantry training systems other than BIFVTS. Initially, BIFVTS will design and deliver "add-on" training in BIFV operations, which training must be compatible with other on-going training that the BIFV learner-operators have or will have received. At a later stage of evolution, BIFVTS will be integrated with other infantry training systems, a step that will require careful coordination with those systems. At present, those systems are collateral to BIFVTS.

- Various U.S. Army infantry units. BIFVTS learners, facilitators and other personnel will be drawn from infantry units. Those units thus are human-machine systems collateral to BIFVTS.

- The Fort Benning Logistic Support System. This entity works closely and often with the Infantry School, although it is functionally distinct from the school. The Fort Benning Logistic Support System will operate a significant portion of the BIFVTS Logistics subsystem, especially during the early stages of BIFVTS operation. In the future, as greater shares of BIFVTS operation move "into the field," the infantry units will take over increasingly more of the Logistics functions in support of training.

- The BIFV itself, together with its full complement of personnel and equipment. The BIFV clearly is an essential collateral system to BIFVTS.

- The Bradley Cavalry Fighting Vehicle Training System (BCFVTS). This is a fraternal twin of BIFVTS, and many of its operations and performance requirements will be identical to those of BIFVTS. Pooling of resources and sharing of information and products between these two systems is highly desirable if not absolutely essential. (Parenthetically, BCFVTS is itself imbedded in an interactive network of systems that exactly parallels the BIFVTS network. A portion of the BCFVTS network is also shown in Figure 10.)

Since BIFVTS is a training system, it must (according to one of the fundamental axioms) incorporate the six general training systems within itself. How are those subsystems structured and operated in BIFVTS?

The BIFVTS Command subsystem is operated and equipped by the BIFV Task Force, an *ad hoc* subsystem of the U.S. Army Infantry School. The BIFV Task Force has been created and staffed to exercise overall responsibility for the design, development, testing, and final production and dissemination of BIFV training. The specific immediate responsibilities of the Task Force are to:

- Identify the specific skills and knowledge required of BIFV operators.

- Develop BIFV training strategies.

- Establish new equipment training (NET) for the BIFV.

- Administer, monitor, and evaluate all BIFV training development, testing, and production.

The reader will recognize that several of the above-listed responsibilities are actually training design functions. Indeed, the BIFVTS Design subsystem also is operated (at present) solely by members of the BIFV Task Force. Their current design work is oriented toward the production of five distinct curricula:

- An "add-on" course for Skill Level 1 BIFV Soldiers (MOS 11M10).

- A Basic Gunnery Course (for Skill Level 2 Soldiers [MOS 11M20] and some Skill Level 1 Soldiers).

- A BIFV Commander's Course (for Skill Levels 3-5 [11M30, 11M40, 11M50] and for officer grades 01-05).

- A transitional new equipment training (NET) course covering the above-listed skill levels.

- A Master Gunner's Course.

The Master Gunner's curriculum principally is intended as an input to the BIFVTS Enabling subsystem. One E7 or E8 from the S3 section of each BIFV mechanized infantry battalion will receive Master Gunnery training, as will one E6 from each BIFV company. The Master Gunner's duties include the administration, supervision and delivery of Basic Gunnery training within his or her unit. The Master Gunner, in effect, will be a field facilitator/administrator within BIFVTS. Other current or planned operations within the BIFVTS Enabling subsystem include the organization and deployment of a team of facilitators to support new equipment training on a transitional basis as the BIFV is introduced into operational units; familiarizing selected mechanized infantry instructor/facilitators with the emerging BIFV curricula; and delivering Mastery Gunnery training.

It is not presently envisioned that the BIFVTS Enabling subsystem will provide formal instructional skills training to all selected facilitators. Instead, persons who are selected to serve as BIFVTS facilitators will be recruited from among those who already possess instructional delivery and guidance skills. Note, however, that this approach in no way changes the performance requirements faced by the Enabling subsystem. That subsystem

still must have the potentiality for insuring that adequate instructional skills resources are provided for BIFVTS Delivery applications. It still must carry out the processes of assessing the candidate facilitators' instructional skills and of diagnosing their needs for improvement and remedial training. It still and always has the responsibility of producing facilitators who are qualified in every respect for their assignments. The decision to recruit experienced instructors rather than to provide basic instructional training to novices is a system design choice that may or may not be optimum in a particular case, depending on the exact circumstances. The design choices taken are simply the variable means to the immutable ends represented by the performance requirements, or taxa. The system evaluator is far less interested in the approaches the designer took and in why those approaches were taken than he or she is in determining whether the system--as designed--does the job it is supposed to do. It may well be (and probably is) an excellent decision of the BIFV Task Force to recruit experienced instructors to serve as BIFV training facilitators. But that decision, for good or ill, does not lessen the BIFVTS Enabling subsystem's responsibility for providing fully qualified facilitators.

The BIFVTS Emplacement subsystem is responsible for the design and selection/fabrication of all audiovisuals and other learning aids necessary to support implementation of the various curricula, and for the acquisition or construction and preparation of all sites at which learning activities will take place, whether in a classroom or field setting. One important element of this responsibility will be the design and construction of gunnery practice ranges. The range requirements presently envisioned include:

- Firing port weapons range
- BIFV Basic Gunners range
- BIFV Squad subcaliber range
- BIFV Squad qualification range
- Platoon qualification attack range
- Platoon qualification defense range

Note that all of the BIFVTS Emplacement subsystem's performance requirements derive from the need to insure that all facilities and materials necessary to support delivery of BIFV training are available and operable at the times and places needed. The Emplacement subsystem designers might determine that the best way to insure the availability of ranges where and when needed is to construct six separate ranges, one for each gunnery requirement. Conversely, they might analyze the proposed Delivery schedules and conclude that two physical ranges will suffice, time-sharing the six requirements between them. The former approach might satisfy the subsystem's product performance requirements, but if it turns out that the ranges are significantly underutilized, the evaluator may conclude that certain analytic process performance requirements were not met, resulting in an expensive, wasteful Emplacement subsystem. Similarly, the two-ranges approach might turn out to have been a brilliant design choice, but not if severe scheduling conflicts arise because the two ranges cannot handle the training load.

The BIFVTS Logistics subsystem presently is operated solely as a component of the Fort Benning logistic support system. In time, increasingly greater shares of the operation of that subsystem will be exercised by various mechanized infantry units in the field.

The BIFVTS Delivery subsystem will allow and insure that learning takes place in the contexts of the various curricula produced by the Design subsystem. Soldiers and officers will carry out prescribed sensory activities, guided and assisted by facilitators, and will achieve the specified performance objectives applicable to their BIFV operational assignments.

BIFVTS thus is a well structured training system, possessing functionally oriented subsystems compatible with the general training model and pursuing a broad range of administrative, developmental, and delivery goals to support the introduction of the new BIFV into the mechanized infantry. It does not detract at all from that image to note that BIFVTS can also be viewed as a loose consortium of smaller scale, relatively independent training systems that pursue more narrowly defined goals. These smaller systems are organized around the five BIFVTS curricula now in development. These systems may be denoted as:

- The BIFV NET System
- The Basic BIFV Soldier Training System
- The Basic BIFV Gunnery Training System
- The Master BIFV Gunnery Training System
- The BIFV Commander Training System

Each of these has its own Command, Design, Enabling, Emplacement, Logistics, and Delivery subsystems. Their development is proceeding more or less in tandem, and there is significant overlap in their objectives, content, and learning activities, as well as in their administration. But they are independent in the sense that any one of them could be developed and operated in the absence of the others. (Admittedly, there wouldn't be much point in designing, developing, and implementing Master Gunnery training if there were to be no Basic Gunnery training, but it still could be done.)

In order to reduce the scope of this trial application to a practical level, the project staff elected to narrow their focus to the Basic BIFV Gunnery Training System. Like all systems, this one operates in the context of an interactive system network of suprasystems, collateral systems, and subsystems. The network is shown in Figure 11. The Basic Gunnery system is subservient to such entities as the U.S. Army Infantry School, the Fort Benning Logistic Support System and, of course, the total BIFVTS. It interacts collaterally with the other four independent BIFV training systems and with portions of U.S. Army Infantry units, namely, those portions from which the E4's and E5's will be recruited as candidate gunners. It also interacts collaterally with the BIFV Carrier Team subsystem. That is the portion of the total BIFV system for which the gunner-learners are to become qualified as operators. And finally, the Basic BIFV Gunnery Training System

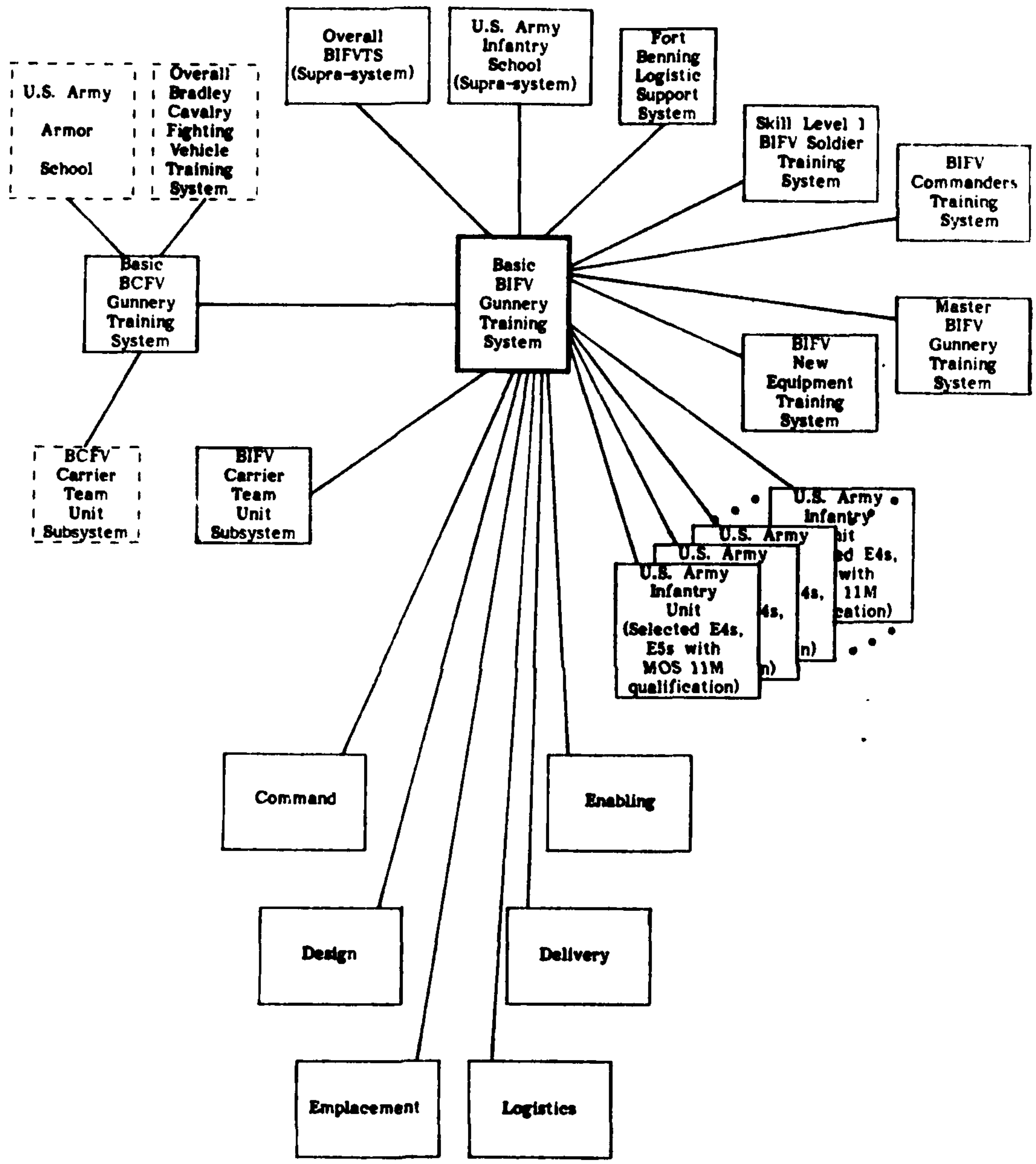


Figure 11. Major Systems Interacting with the Basic BIFV Gunnery Training System

has a fraternal (collateral) twinship with the Basic BCFV Gunnery Training System. The subsystems of Basic BIFV Gunnery Training are, of course, the six familiar subsystems of Command, Enabling, Design, Emplacement, Logistics, and Delivery.

Even this narrowed focus remains too broad for a trial measurement application. Thus far in the present research, performance taxa have been identified only for two of the six training subsystems. The tools are not yet available to permit assessment of a total training system's performance, not even one concerned with such a specific issue as BIFV Gunnery training. It is necessary to narrow the focus further, to select measurement issues lodged strictly within one of the two subsystems for which taxa now are known.

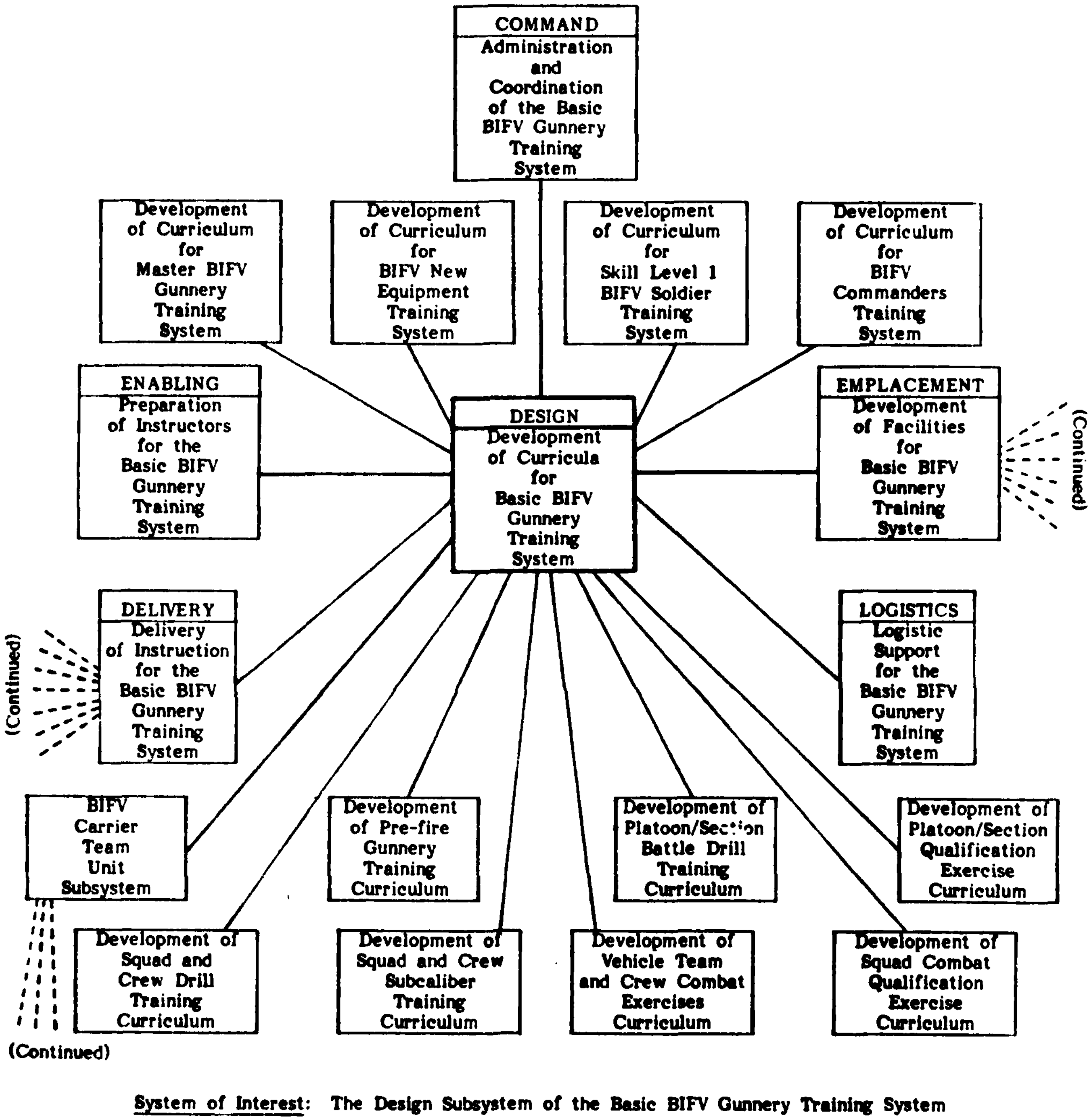
We choose to address the Design Subsystem of BIFV Basic Gunnery Training, rather than the Enabling Subsystem, because of the following considerations:

- Design operations are at a further stage of development than are Enabling operations. Any inputs that this research can provide for assessing Design performance would be more timely for the BIFV Task Force than would inputs to assessment of Enabling performance.

- Many of the performance requirements of the Enabling subsystem relate to the facilitators' interaction with the products of the Design subsystem. Thus, it is logical to establish first that Design has achieved its performance requirements before attending to Enabling subsystem performance.

- As a collateral to all of the other training subsystems, Design performance has a marked effect on the work that the other subsystems can accomplish. Any strides that can be made now toward measurement of the Gunnery Design subsystem will provide a firmer base for future applications of the APM to BIFVTS and other training systems.

Figure 12 depicts the network of systems that interact most closely with the Design subsystem of Basic BIFV Gunnery Training. As in any training system, Gunnery Training Design is subservient to the Command subsystem, and collateral to the Enabling, Emplacement, Logistics, and Delivery subsystems. Key sub-subsystems of both Emplacement and Delivery have been included in Figure 12 to emphasize the special gunnery instruction and practice requirements that must be reflected in Design's products. Gunnery Training Design is also collateral to the Design subsystems of the other BIFV Training "packages." This is because all of those packages share some performance objectives, learning activities, etc., with gunnery training.



(Continued →)

Figure 12. Sample Hierarchical Structure Centered on a Subsystem of a Training System

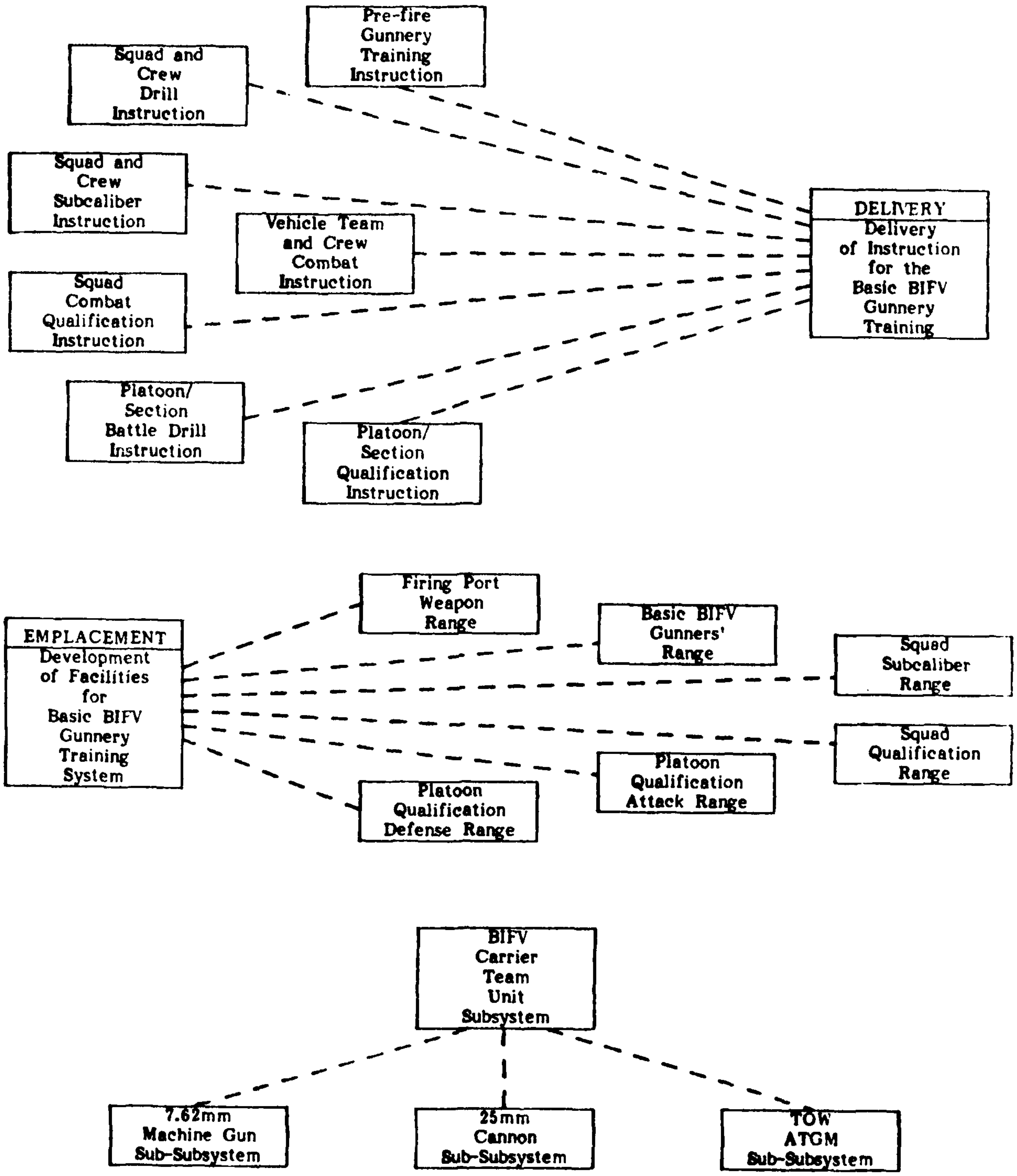


Figure 12. Sample Hierarchical Structure Centered on a Subsystem of a Training System (Cont'd)

The sub-subsystems of Gunnery Training Design correspond to the thus far identified segments of the gunnery curriculum. These represent the sequential stages of learning through which BIFV gunner-learners must pass to become fully qualified. The initial stages stress individual training; the latter, team training.

2. The Measurement Application: Specification of Gunner-Learner Testing

Having selected the Design subsystem of Basic BIFV Gunnery Training as the system of interest for this trial, it remains to select an issue of focus for the application. It would be possible, if sufficient resources were available, to examine the global performance of the Design subsystem, i.e., simply to ask, "How well does the Gunnery Training Design meet all of its performance requirements?" Within the scope of this present study, and given the current state of APM application procedures, development of a comprehensive and complete measures set would be unreasonably consumptive of project time and funds. A more restricted measurement application seems in order, i.e., an assessment of how well Design meets some limited aspect of its performance requirements. Of course, it is highly desirable to insure that the aspect chosen for study is of interest and value to the BIFV Task Force.

What, then, are some typical aspects of Gunnery Training Design performance? What are the issues that might be of interest to system designers and evaluators?

Recall that the fundamental function of any training system is learning. Everything that goes on anywhere in any training system, or in any of its subsystems, is supposed to contribute in some way to learning. Anything within the system that detracts from or degrades learning is a system defect. At rock bottom, all assessments of training system or subsystem performance must supply some portion of the answer to this fundamental question: Did the learners learn what they were supposed to learn?

What does Design contribute to learning? What light can an examination of Design performance shed on the quality and quantity of learning that the system delivers?

Design's basic job is to provide training specifications. It specifies what is to be learned, i.e., the goals and (especially) the performance objectives that learners are supposed to achieve. It specifies the context of learning, i.e., the content of knowledge, abilities, and attitudes required of the learning and the informational material that manifests the content. It specifies the learning activities, i.e., the sensory experiences that will affect the learners' behavior in the intended manner. The quality and quantity of learning will suffer to the extent to which Design badly specifies what is to be learned (e.g., produces poorly or erroneously stated performance objectives); or to the extent to which Design badly specifies the learning context (e.g.,

by including topical material that has no bearing on the performance objectives, thereby confusing the learners); or to the extent to which Design badly specifies the learning activities (e.g., devises activities that produce unexpected, deleterious effects on learners' behavior). Any issue that pertains to some component of Design's specification of the learning objectives, context, or activities is one very worth exploring.

The issue selected for this trial application is Gunnery Training Design performance in specifying gunner-learner testing. That is a sub-issue of its performance in specifying learning activities. The other sub-issues of that heading are: specifying gunner-learner preparation activities; specifying activities for making presentations (or demonstrations) to gunner-learners; and specifying gunner-learner application (or practice) activities. Virtually all learning theorists* agree that preparation, presentation, application, and evaluation (or testing) constitute the four classes of learning activities.

*See Bibliography for representative documents.

The issue of how well a Design subsystem specifies learner testing procedures is of special importance in any training system. Certainly, that issue will affect the appropriateness of decisions made by facilitators and learners themselves concerning whether particular learners need more training, or any training at all, to achieve particular performance objectives. Even more significantly, it will affect the appropriateness of the system's certification of learners as competent job performers, thus affecting the entire training system's reputation. Most basically, if deficient learner testing specifications are produced by the Design subsystem, the entire training system will be at a loss as to assessing its most fundamental performance requirement: it will not really know whether the learners have learned. Thus, no training system can afford to allow its Design subsystem to produce poor measures of learners' achievements. The Basic BIFV Gunnery Training System is no exception.

Before moving on to the next step in this trial application, in which particular performance taxa associated with learner testing specification will be identified, it is worthwhile to set the stage by informally reviewing some of the requirements and implications of learner testing in any training application. The following, at least, seem almost self-evident:

- <u>Testing must be objectives-referenced</u>

  The purpose of testing is to evaluate learners' progress toward or achievement of the performance objectives, i.e., that which is to be learned. No performance objective should go untested. No test that does not relate to some performance objective should be included.

- Testing must be criteria-referenced

It is not enough that a test simply requires the learner to exercise the behavior called for in a performance objective. The test must disclose whether the behavior is performed "well enough" to satisfy learning needs.

- Some kind of pre-training testing is necessary

All training assumes some prerequisite behavior. If nothing else, it is always assumed that the learner is able to carry out the sensory activities called for in the training. Many training applications admit the possibility that some learners may already have achieved certain of the specified performance objectives. There is no point in commencing training unless the learner first is tested to insure that he or she possesses the assumed prerequisites. A very informal test might suffice for that purpose, perhaps only a records check or even a cursory visual examination of the learner, but some testing for prerequisites surely is needed. When there is reason to believe that some learners may already have achieved the learning objectives, pre-testing of those objectives also will be necessary.

- Some testing for feedback is necessary

Testing is after all a learning activity. Learners need to know how well they are doing in order to progress and persevere. Any training system should provide at least some testing for the purpose of feeding back progress and diagnosis information to the learners.

- Testing must diagnose learning deficiencies

It is not sufficient that tests disclose that a learner cannot perform the intended behavior. In order to provide meaningful feedback to the learner and to facilitate subsequent improvement of the curriculum and the delivery, tests that diagnose the specific ingredients of substandard learner performance must be included in the specifications. Only then can the learner's performance be corrected and brought up to standard.

- Testing must be reflective of on-the-job performance

The tests specified must require the learners to manifest the job-relevant behaviors under job-relevant conditions. The testing conditions should resemble job conditions as closely as possible, since the test outcome otherwise may not be a valid predictor of the learner's job performance.

- Some kind of qualification testing is necessary

  No learner should be "certified" as having successfully completed training unless he or she demonstrates, through testing, that the performance objectives have been achieved. Depending on the circumstances of the particular training experience, the qualification testing might be formal or informal, but some testing surely is needed.

The preceding list is an "off-the-top-of-the-head" compilation of factors that probably would occur to any evaluator interested in measuring the adequacy of a Design subsystem's learner testing specifications. What follows is an attempt to impose analytic rigor upon the measurement process.

3. Design Subsystem Performance Taxa Relevant to Measurement of the Adequacy of Gunner-learner Testing Specifications

Two hundred and eighty-one taxa of Design Subsystem performance requirements are listed in Figure 7, above. These are distributed among the three aspects of performance (potentialities, processes, and products) and across the three levels of system description (objectives, functional purposes, and characteristics). Some of the 281 taxa are relevant to evaluation of a Design Subsystem's performance in specifying learner testing. Others are not. At the present stage of development of the APM, well defined procedures for determining which taxa do or do not bear on a given measurement application are yet to be established. Indeed, one purpose of this trial application is to add to the base of experience from which such procedures may be derived. Currently, assessment of taxa relevance is a "judgment call" by an analyst or team of analysts working together. The thought process can be described as follows: "Here we have some aspect of this system's performance, and over here we have a performance taxon for the system. That taxon represents a particular requirement that the system is supposed to satisfy. Suppose the system does a bad job in trying to satisfy that requirement. Might that have any bearing on the particular aspect that we are studying?" If the analyst concludes that the answer is "yes," the taxon in question would be included among the subset from which measurement issues and implications, and ultimately measures, will be derived. If the answer is "no," the particular taxon will supply no input to the measurement application at hand. Identification of relevant taxa, then, is a step-by-step march through an entire system taxonomy, during which each taxon is picked up in turn, examined from various angles, and finally accepted or rejected in accordance with whether or not it appears to the analyst to have something of interest to say. This process can be streamlined somewhat, simply by examining only the characteristics-level taxa. If a taxon on the characteristics level is found to be relevant to the particular measurement application, then the functional purposes-level taxon from which it derives also must be relevant. A characteristics-level taxon, after all, is simply a detailed performance requirement that the system must satisfy if it is to achieve the related

functional purpose. Thus, the functional purpose must be subsumed under the aspect of performance being studied. Similarly, if a functional purposes-level taxon is relevant to the measurement application, so must be the objectives-level taxon from which it derives. The functional purpose, after all, is only a required application of the basic potentiality, process, or product defined on the objectives level. For example, if the analyst in using Figure 7 were to conclude that taxon number 2.1.3.1 (a characteristics-level process requirement) is of significance to the measurement application, he or she would automatically know that taxa 2.1.3 and 2.1 (its functional purposes-level and objectives-level antecedents) also are relevant. These inter-relationships are described in more detail in the Year 1 Final Report (Bloom, et. al., 1981).

Appendix A of this report documents the examination of every characteristics-level taxon of potentiality of the general Training Design subsystem for possible relevance to assessment of the subsystem's performance in specifying learner testing. Rationale for concluding whether an individual taxon is or is not relevant to the measurement issue is presented there. Similar (but undocumented) examinations were made of the process and product taxa. The final conclusion of these examinations was that 119 of the 281 taxa are relevant to evaluation of the Design Subsystem's specifications of learner testing. Those relevant taxa form 14 taxonomic subsets, of which 5 are potentialities, 3 are processes, and 6 are products. Figure 13 arrays these subsets, displaying their member taxa as issues relevant to evaluation of learner testing specifications.

4. Addressing the Issues: Attributes and Measures of the Adequacy of Gunner-Learner Testing Specifications

Alongside each of the evaluative issues arrayed in Figure 13, the reader will find a set of attributes deemed to be relevant to the particular issue. Referring to the overall APM (Figure 1), the issues listed in Figure 13 derive from Blocks 1-3, whereas their correlated attributes for potential measurement are the result of carrying out the Block 6 operations. Each attribute is a concrete element of the Design subsystem's work. It is something that can be seen, examined, submitted to analysis, taken apart, etc. In short, each attribute is something that is measurable. Further, each attribute is something that, when measured, can supply a portion of the answer to the question posed in the evaluative issue.

Some examples may help to clarify the relationship between issues and attributes. Consider first the final issue in Subset No. 1 (Figure 13), namely, "Can the BIFV Gunnery Training Design subsystem insure that the training goals will be stated in terms that imply the gunner behaviors required, so that the testing specifications ultimately may address those behaviors?" This issue arises from a characteristics-level potentiality, i.e., the potential for stating goals in behavioral-implication terms. That is a particularly important capability for test specification. Each gunnery test will require the gunner-learners to manifest some behavior, for instance a behavior

PART 1: ISSUES AND ATTRIBUTES OF POTENTIALITIES

Subset No. 1: "Identifying Goals and Priorities"

	Issues	Attributes
1.1	Does the system have the ability to insure that all gunnery training goals will be identified so that they may be addressed in gunner testing specifications?	° Scope of information available concerning BIFV gunnery operations ° Staff experience and qualifications in the identification of training goals ° The planned approach to identifying BIFV gunnery training goals ° The resources allocated to identifying BIFV gunnery training goals
1.1.1	Can the system insure that the total *scope of learning* required for each gunnery training goal will be defined so that the full scope of each goal may be covered in the testing specifications?	° The elements or aspects of each gunnery training goal intended to be defined ° The plans for defining the total scope of BIFV gunnery learning
1.1.1.1	Can the system insure that all achievements constituting the scope of BIFV gunnery learning will be identified so that the testing specifications may address each achievement?	° The types or classes of achievement intended to be identified ° The plans for identifying all types of BIFV gunnery achievements
1.1.2	Can the system insure that the ultimate intended outcomes of BIFV gunnery learning can be stated so that appropriate tests of those outcomes may be specified?	° Elements of ultimate outcomes that are intended to be stated ° Intended formats for stating the ultimate intended outcomes of BIFV gunnery learning ° The plans for stating the ultimate intended outcomes
1.1.2.1	Can the system insure that the necessary levels of achievement for acceptable BIFV gunnery can be determined, so that the specified tests may assess whether whether those levels are reached?	° Elements or factors of the necessary *levels intended to be determined* (i.e., factors of acceptability) ° The plans for determining the necessary levels of BIFV gunnery achievement
1.1.2.2	Can the system insure that candidate gunners' current levels of achievement can be tested to help determine learning needs?	° *Elements or factors of* the current levels of achievement intended to be tested ° The plans for testing candidates' current levels of BIFV gunnery achievement
1.1.4	Can the system insure that the goals will be analyzed to produce a basis for specifying BIFV gunnery performance objectives?	° Elements of the basis intended to be established ° Plans for establishing the basis for specifying BIFV gunnery performance objectives
1.1.4.1	Does the system propose to use an appropriate taxonomy for classifying goals in a fashion conducive to establishing correct performance objectives and correspondingly correct testing specifications?	° Goal taxa intended to be employed ° Plans for employing the taxa to classify goals for BIFV gunnery training
1.1.4.2	Can the system insure that goals will be stated in terms that imply the gunner behaviors required, so that the testing specifications ultimately may address those behaviors?	° Behavioral terminology intended to be used in stating BIFV gunnery training goals ° Intended formats for stating BIFV gunnery training goals

Figure 13. Measurement Issues and Measurable Attributes Relevant to Evaluation of BIFV Gunnery Testing Specifications

Subset No. 2: "Establishing Performance Objectives"

	Issues	Attributes
1.2	Does the system have the ability to insure that all BIFV gunnery performance objectives will be identified so that they may be addressed in gunner testing specifications?	° Scope of information available concerning BIFV gunners' tasks ° Staff experience and qualifications in establishing performance objectives ° The planned approach to establishing BIFV gunnery performance objectives ° The resources allocated to establishing BIFV gunnery performance objectives
1.2.1	Can the system insure that all things BIFV gunners will be able to do after training will be stated, so that tests of all required abilities may be specified?	° The elements or factors of gunner abilities intended to be stated ° Intended formats for stating BIFV gunner abilities ° The plans for stating intended abilities
1.2.1.1	Can the system insure that the stated abilities will include definitions of the required gunner actions, so that the test specifications may address those actions?	° The types of performance actions intended to be defined ° The plans for defining actions required of BIFV gunners
1.2.1.2	Can the system insure that the stated abilities will include definitions of the appropriate conditions under which BIFV gunners are to perform the actions, so that the test specifications may reflect those conditions?	° The elements or factors of performance condition intended to be defined ° The plans for defining BIFV gunnery performance conditions
1.2.1.3	Can the system insure that the stated abilities will include definitions of the appropriate standards of acceptable performance of the BIFV gunner actions, so that the test specifications may incorporate those standards?	° Elements or factors of performance standards intended to be defined ° The plans for defining standards for BIFV gunnery performance actions
1.2.2	Can the system insure that the identified BIFV gunnery performance objectives will be applied to provide a basis for objectively assessing gunners' performances?	° Elements of the basis for assessment intended to be provided ° Plans for providing a basis for objectively assessing BIFV gunners' performances
1.2.2.1	Can the system insure that appropriate pretest items addressing the performance objectives will be developed, so that they may be included in the testing specifications?	° Types of BIFV gunnery pretest items intended to be developed ° Plans for developing BIFV gunnery pretest items
1.2.2.2	Can the system insure that appropriate posttest items addressing the performance objectives will be developed, so that they may be included in the testing specifications?	° Types of BIFV gunnery posttest items intended to be developed ° Plans for developing BIFV gunnery posttest items

Figure 13. (Continued)

Subset No. 3: "Analyzing Performance Objectives"

	Issues	Attributes
1.3	Does the system have the ability to insure that all BIFV gunnery performance objectives will be analyzed to determine the specific elements of gunner performance that need to be tested?	° Intended scope of analysis of BIFV gunnery performance objectives ° Staff experience and qualifications in analyzing performance objectives ° The planned approach to analyzing BIFV gunnery performance objectives ° The resources allocated to analyzing BIFV gunnery performance objectives
1.3.1	Can the system insure that the analysis of BIFV gunnery performance objectives will disclose the gunnery training prerequisites, so that appropriate tests of candidate gunners may be specified?	° Types or classes of BIFV gunnery prerequisites intended to be identified ° Plans for identifying BIFV gunnery training prerequisites
1.3.1.1	Can the system insure that the analysis will uncover what candidate gunners must recall in order to be qualified for training, so that appropriate tests of that recall may be specified?	° Types of information recall requirements intended to be revealed ° Plans for revealing the BIFV gunners' recall requirements
1.3.1.2	Can the system insure that the analysis will uncover abilities that the candidate gunners absolutely must possess in order to achieve the performance objectives, so that appropriate tests of those abilities may be specified?	° Types of essential prerequisite abilities intended to be revealed ° Plans for revealing the BIFV gunners' essential prerequisite abilities
1.3.1.3	Can the system insure that the analysis will uncover abilities which, if possessed by candidate gunners, will facilitate achievement of the performance objectives, so that appropriate tests of those abilities may be specified?	° Types of supportive prerequisite abilities intended to be revealed ° Plans for revealing the BIFV gunners' supportive prerequisite abilities
1.3.2	Can the system insure that the analysis of performance objectives will be applied to provide a basis for objectively assessing a candidate gunner's suitability for training?	° Elements of the basis for candidate assessment intended to be provided ° Plans for providing a basis for objectively assessing a candidate BIFV gunner's suitability for training
1.3.2.1	Can the system insure that appropriate entry test items addressing candidate BIFV gunners' suitability will be included in the testing specifications?	° Scope of BIFV gunner abilities intended for entry testing ° Plans for specifying entry test items for candidate BIFV gunners
1.3.4	Can the system insure that performance objectives will be classified into appropriate domains of learning, so that tests specified for each objective may exercise the appropriate domain?	° Domains of learning intended for use in classifying BIFV gunnery performance objectives ° Plans for classifying BIFV gunnery performance objectives into learning domains

Figure 13. (Continued)

Subset No. 3 (Cont'd)

	Issues	Attributes
1.3.4.1	Can the system insure that all information-type objectives will be correctly classified, so that appropriate information-type tests may be specified for them?	° Criteria intended to be employed for classifying BIFV gunnery performance objectives as information-type objectives
1.3.4.2	Can the system insure that all mental skills-type objectives will be correctly classified, so that appropriate mental skills-type tests may be specified for them?	° Criteria intended to be employed for classifying BIFV gunnery performance objectives as mental skills-type objectives
1.3.4.3	Can the system insure that all physical skills-type objectives will be correctly classified, so that appropriate physical skills-type tests may be specified for them?	° Criteria intended to be employed for classifying BIFV gunnery performance objectives as physical skills-type objectives
1.3.4.4	Can the system insure that all attitude-type objectives will be correctly classified, so that appropriate attitude-type tests may be specified for them?	° Criteria intended to be employed for classifying BIFV gunnery performance objectives as attitude-type objectives
1.3.5	Can the system insure that the analysis of BIFV gunnery performance objectives will identify the component steps or processes required of BIFV gunners, so that tests of the gunners' abilities to perform those component steps or processes may be specified?	° Types or classes of gunners' component steps or processes intended to be identified ° Plans for identifying gunners' component steps or processes within the BIFV gunnery performance objectives
1.3.5.1	Can the system insure that all overt steps required of BIFV gunners will be identified, so that they may be addressed in the testing specifications?	° Types of overt steps intended to be identified ° Plans for identifying the overt steps involved in BIFV gunnery performance objectives
1.3.5.2	Can the system insure that all covert steps required of BIFV gunners will be identified, so that they may be addressed in the testing specifications?	° Types of covert steps intended to be identified ° Plans for identifying the covert steps involved in BIFV gunnery performance objectives
1.3.5.3	Can the system insure that all unconscious steps required of BIFV gunners will be identified, so that they may be addressed in the testing specifications?	° Types of unconscious steps intended to be identified ° Plans for identifying the unconscious steps involved in BIFV gunnery performance objectives

Figure 13. (Continued)

Subset No. 4: "Defining Training Procedures"

	Issues	Attributes
1.5	Does the system have the ability to insure that all BIFV gunnery training procedures will be correctly defined, so that gunnery testing procedures will play their proper role in BIFV gunnery training?	° Categories or types of BIFV gunnery training procedures intended to be defined ° Staff experience and qualifications in the definition of training procedures ° The planned approach to defining BIFV gunnery training procedures ° The resources allocated to defining BIFV gunnery training procedures
1.5.3	Can the system insure that BIFV gunner application (or practice) procedures will be correctly specified, so that the role of testing-in-practice will be properly defined and reflected in the testing specifications?	° Classes/methods of BIFV gunnery application intended to be specified ° Intended involvement of testing in BIFV gunnery application ° Plans for specifying BIFV gunnery application procedures
1.5.3.4	Can the system insure that the application (practice) procedures will provide learning feedback to the BIFV gunner-learners?	° Intended role of learning feedback in the BIFV gunnery application procedures ° Intended contribution of testing to BIFV gunnery learning feedback ° Plans for providing for BIFV gunnery learning feedback
1.5.3.5	Can the system insure that the application (practice) procedures will enable the BIFV gunner-learners to assess sufficiency of practice?	° Criteria intended to be employed in assessing sufficiency of practice ° Intended contribution of testing to the employment of those criteria ° Plans for enabling BIFV gunner-learners to assess sufficiency of practice
1.5.4	Can the system insure that BIFV gunner evaluation (or testing) procedures will be correctly defined, so that those definitions may be reflected in the testing specifications?	° Categories/methods of BIFV gunnery evaluation intended to be specified ° Plans for specifying BIFV gunnery evaluation procedures
1.5.4.1	Can the system insure that the BIFV gunner tests that are specified will address the appropriate domains of BIFV gunnery learning?	° Plans for tailoring test specifications to the domain of the objective to be tested
1.5.4.2	Can the system insure that the BIFV gunner tests that are specified will elicit the appropriate actions from the BIFV gunner-learners?	° Plans for tailoring test specifications to the action called for in the objective to be tested
1.5.4.3	Can the system insure that the BIFV gunner tests that are specified will provide a reliable assessment of the BIFV gunner-learners' performances?	° Plans for tailoring test specifications to the conditions and standards appropriate to the objective to be tested ° Plans for devising test specifications that will support statistical reliability requirements

Figure 13. (Continued)

Subset No. 5: "Evaluating the Curriculum"

	Issues	Attributes
1.6	Does the system have the ability to insure that the BIFV gunnery training curriculum will be properly evaluated, and in particular that all BIFV gunner testing appropriate to curriculum evaluation will be specified and conducted?	° Intended scope of BIFV gunnery training curriculum evaluation ° Staff experience and qualifications in evaluation of training curricula ° The planned approach to evaluating the BIFV gunnery training curriculum ° The resources allocated to evaluating the BIFV gunnery training curriculum
1.6.1	Can the system insure that all appropriate steps will be taken to validate/revise the bases for the developing BIFV gunnery training curriculum, including in particular the specification and conduct of BIFV gunner testing appropriate to that validation/revision?	° Intended elements/methods of curriculum basis validation/revision to be employed ° Intended contribution of BIFV gunner testing to those elements/methods ° Plans for validating/revising the bases for the developing BIFV gunnery training curriculum
1.6.1.1	Can the system insure that all appropriate entry-level testing of representative candidate BIFV gunners will be specified and conducted to verify assumptions concerning prerequisites and candidates' qualifications?	° Assumptions concerning prerequisites and candidates' qualifications intended to be verified ° Intended contribution of BIFV entry-level gunner testing to that verification ° Plans for specifying and conducting BIFV entry-level gunner testing to verify the assumptions
1.6.1.2	Can the system insure that all appropriate post-training testing of representative current BIFV gunners will be specified and conducted to verify conclusions concerning the performance objectives and the tests specified for those objectives?	° Conclusions concerning performance objectives and test specifications intended to be verified ° Intended contribution of BIFV post-training testing to that verification ° Plans for specifying and conducting BIFV post-training testing to verify the conclusions
1.6.2	Can the system insure that all appropriate steps will be taken to validate/revise the developing BIFV gunnery training curriculum itself, including in particular the specification and conduct of BIFV gunner testing appropriate to that validation/revision?	° Intended elements/methods of curriculum validation/revision to be employed ° Intended contribution of BIFV gunner testing to those elements/methods ° Plans for validating/revising the developing BIFV gunnery training curriculum
1.6.2.1	Can the system insure that all appropriate testing of "pilot training" BIFV gunner-learners will be specified and conducted, so that necessary error data on the specified tests may be obtained?	° Aspects/segments of the curriculum intended for "pilot training" ° Intended role of BIFV gunner testing in "pilot training" ° Plans for specifying and conducting BIFV gunner testing in conjunction with "pilot training"
1.6.2.2	Can the system insure that "pilot training" gunner-learners' performance on the specified tests will be correlated with subsequent job performance measures, so that the predictive validity of the specified tests may be assessed?	° Aspects/segments of the curriculum for which job performance measures are intended to be developed ° Plans for correlating job performance measures with "pilot training" gunner-learners' test scores

Figure 13. (Continued)

PART 2: ISSUES AND ATTRIBUTES OF PROCESSES

Subset No. 6: "Analyze Tasks Selected for Training"

	Issues	Attributes
2.3	Does the system conduct a proper analysis of BIFV gunner tasks, so that appropriate tests of those tasks may be specified?	° The task analytic methods applied to the BIFV gunner tasks ° The scope of the task analyses conducted (i.e., factors determined in the analyses) ° The completeness of the BIFV gunner task analyses ° The accuracy of the BIFV gunner task analyses
2.3.2	Does the system accurately identify the domains of learning involved in the BIFV gunner tasks, so that tests may be specified and developed in the proper domains?	° Methods employed to identify the domains of learning involved in the BIFV gunner tasks ° The domains of learning identified for each BIFV gunner task
2.3.2.1	Does the system accurately identify the knowledge that BIFV gunners must acquire to perform their tasks, so that appropriate tests of knowledge may be specified and developed?	° Methods employed to identify the the knowledge requirements associated with BIFV gunner tasks ° The BIFV gunner task knowledge requirements identified
2.3.2.2	Does the system accurately identify the mental skills that BIFV gunners must acquire to perform their tasks, so that appropriate tests of mental skills may be specified and developed?	° Methods employed to identify the mental skills requirements associated with BIFV gunner tasks ° The BIFV gunner task mental skills requirements identified
2.3.2.3	Does the system accurately identify the physical skills that BIFV gunners must acquire to perform their tasks, so that appropriate tests of physical skills may be specified and developed?	° Methods employed to identify the physical skills requirements associated with BIFV gunner tasks ° The BIFV gunner task physical skills requirements identified
2.3.2.4	Does the system accurately identify the attitudes that BIFV gunners must acquire to perform their tasks, so that appropriate tests of attitude may be specified and developed?	° Methods employed to identify the attitudinal requirements associated with BIFV gunner tasks ° The BIFV gunner task attitudinal requirements identified
2.3.3	Does the system accurately identify the conditions for learning associated with the BIFV gunner tasks, so that appropriate tests may be specified and developed for assessing candidate gunners' qualifications?	° Methods employed to identify the conditions for learning the BIFV gunner tasks ° Types of conditions for learning identified for each BIFV gunner task
2.3.3.1	Does the system accurately identify BIFV gunners' prerequisite knowledge, so that appropriate tests of the knowledge prerequisites may be specified and developed?	° Methods employed to identify the prerequisite knowledge required for learning the BIFV gunner tasks ° Knowledge items identified as prerequisite for learning the BIFV gunner tasks

Figure 13 (Continued)

Subset No. 6 (Cont'd)

Issues		Attributes
2.3.3.2	Does the system accurately identify BIFV gunners' prerequisite mental skills, so that appropriate tests of the mental skills prerequisites may be specified and developed?	• Methods employed to identify the prerequisite mental skills required for learning the BIFV gunner tasks • Specific mental skills identified as prerequisite for learning the BIFV gunner tasks
2.3.3.3	Does the system accurately identify BIFV gunners' prerequisite physical skills, so that appropriate tests of the physical skills prerequisites may be specified and developed?	• Methods employed to identify the prerequisite physical skills required for learning the BIFV gunner tasks • Specific physical skills identified as prerequisite for learning the BIFV gunner tasks
2.3.3.4	Does the system accurately identify BIFV gunners' prerequisite attitudes, so that appropriate tests of the attitudinal prerequisites may be specified and developed?	• Methods employed to identify the prerequisite attitudes required for learning the BIFV gunner tasks • Specific attitudes identified as prerequisite for learning the BIFV gunner tasks

Figure 13 (Continued)

Subset No. 7: "Determine Instructional Requirements"

	Issues	Attributes
2.4	Given the results of the analysis of the tasks selected for training, does the system properly determine the BIFV gunnery instructional requirements, including in particular the requirements for testing gunner-learners?	° The methods employed to determine instructional requirements from the results of the analysis of BIFV gunner tasks ° The types of instructional requirements determined ° The completeness of the methods' applications ° The accuracy of the methods' applications
2.4.1	Does the system accurately identify all required BIFV gunnery learning activities/events, so that the proper role of testing in those activities/events may be specified?	° The methods employed to identify required BIFV gunnery learning activities/events ° The BIFV gunnery learning activities/events identified as required
2.4.1.4	Does the system accurately identify the gunner testing components of the required BIFV gunnery learning activities/events?	° Methods employed to identify components of gunner testing included within required BIFV gunnery learning activities/events ° The gunner testing identified as components of the required BIFV gunnery learning activities/events
2.4.4	Does the system accurately identify all needs for testing BIFV gunner-learners in conjunction with BIFV gunnery training? (This is in addition to needs for testing as component parts of BIFV gunnery learning activities/events.)	° The methods employed to identify requirements for BIFV gunnery testing in conjunction with BIFV gunnery training ° The types of gunnery testing needs identified
2.4.4.1	Does the system accurately identify all needs for testing candidates for acceptance as BIFV gunner-learners?	° Methods employed to identify acceptance-testing requirements ° Identified needs for acceptance-testing of BIFV gunner-learner candidates
2.4.4.2	Does the system accurately identify all needs for testing accepted BIFV gunner-learners to assess their requirements for remedial training?	° Methods employed to identify testing needed to assess remedial training requirements ° Identified needs for testing accepted BIFV gunner-learners to assess their remedial training requirements
2.4.4.3	Does the system accurately identify all needs for testing accepted BIFV gunner-learners to assess possible requirements for tailoring the training to their abilities and experience?	° Methods employed to identify testing needed to assess possible training tailoring requirements ° Identified needs for testing accepted BIFV gunner-learners to assess possible training tailoring required for them

Figure 13. (Continued)

Subset No. 7: (Cont'd)

Issues		Attributes
2.4.4.4	Does the system accurately identify all needs for testing BIFV gunner-learners during training to assess requirements for advancing or delaying their progress through the training?	° Methods employed to identify testing needed to assess learner advancement requirements ° Identified needs for testing BIFV gunner-learners to assess their training advancement status
2.4.4.5	Does the system accurately identify all needs for testing BIFV gunner-learners at completion of scheduled training to assess their qualifications for certification as BIFV gunners?	° Methods employed to identify gunner certification testing requirements ° Identified needs for testing BIFV gunner-learners to determine their certification status

Figure 13. (Continued)

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Subset No. 8: "Conduct Training Trials"

	Issues	Attributes
2.7	Does the system appropriately conduct trials of BIFV gunnery training, including in particular trials of gunnery testing?	° The aspects/segments of BIFV gunnery training submitted to trial ° The kinds of trials conducted ° The role of gunner-learner testing in the trials ° The appropriateness of the trials ° The completeness of the trials ° The reliability of the trials
2.7.2	Does the system adequately and accurately verify the suitability of the assembled instruction for delivery, including in particular the testing segments of instruction?	° Methods employed to verify the suitability of the BIFV gunnery instruction for delivery ° The role of gunner-learner testing in those methods ° Conclusions reached concerning the suitability for delivery
2.7.2.1	Does the system conduct appropriate field tests of the assembled BIFV gunnery instruction, including field tests of the testing specifications?	° Kinds of field tests conducted of the assembled BIFV gunnery instruction ° Information gleaned from field tests ° The role of gunner-learner testing in the field tests

Figure 13. (Continued)

Subset No. 9: "Documented Job Analyses"

	Issues	Attributes
3.1	Does the system produce documented analyses of the BIFV gunner's jobs that completely define the performance elements essential for adequate gunnery, so that tests of those elements may be specified?	° The BIFV gunner job analyses documented ° The elements of BIFV gunner performance identified in the documentation ° The completeness of the documents ° The accuracy of the documents
3.1.1	Does the system produce a complete specification of the performance elements of the BIFV gunner's jobs in sufficient detail to permit those elements to be tested?	° BIFV gunner performance elements for which detailed specifications are produced ° Types of details specified for each performance element
3.1.1.1	Does the system produce accurate specifications of all BIFV gunner mental processes to the level of binary decisions, so that tests of those decisions may be constructed?	° BIFV gunner mental processes specified to the level of binary decisions ° The binary decisions specified for each BIFV gunner mental process
3.1.1.2	Does the system produce accurate specifications of all BIFV gunner physical processes to the level of discrete actions, so that tests of those actions may be specified?	° BIFV gunner physical processes specified to the level of discrete actions ° The discrete actions specified for each BIFV gunner physical process
3.1.1.3	Does the system produce accurate specifications of the stimuli for all BIFV gunner processes, so that those stimuli may be incorporated into the tests of those processes?	° BIFV gunner processes for which stimuli are specified ° The stimulus specified for each BIFV gunner process
3.1.1.4	Does the system produce accurate specifications of the conditions under which BIFV gunners perform their processes, so that those conditions may be incorporated into the tests of those processes?	° BIFV gunner processes for which conditions are specified ° The conditions specified for each BIFV gunner process
3.1.3	Does the system produce a complete specification of the factors that the BIFV gunner-learners' performance elements must satisfy for adequate gunnery?	° BIFV gunner performance elements for which adequacy factors are specified ° Types of adequacy factors specified for each performance element
3.1.3.1	Does the system produce correct specifications of the accuracy requirements associated with BIFV gunners' performance, so that tests can be designed to assess whether sufficient accuracy is achieved?	° BIFV gunner processes for which accuracy requirements are specified ° The accuracy requirements specified for each BIFV gunner process
3.1.3.2	Does the system produce correct specifications of the speed requirements associated with BIFV gunners' performance, so that tests can be designed to assess whether sufficient speed is achieved?	° BIFV gunner processes for which speed requirements are specified ° The speed requirements specified for each BIFV gunner process

Figure 13. (Continued)

Subset No. 9: (Cont'd)

Issues	Attributes
3.1.3.3 Does the system produce correct specifications of the volume requirements associated with BIFV gunners' performance, so that tests can be designed to assess whether sufficient volume is achieved?	° BIFV gunner processes for which volume requirements are specified ° The volume requirements specified for each BIFV gunner process
3.1.3.4 Does the system produce correct specifications of the duration requirements associated with BIFV gunners' performance, so that tests can be designed to assess whether sufficient duration is achieved?	° BIFV gunner processes for which duration requirements are specified ° The duration requirements specified for each BIFV gunner process

Figure 13. (Continued)

Subset No. 10: "Stated Performance Objectives"

	Issues	Attributes
3.2	Does the system produce accurate and complete statements of the performance objectives that BIFV gunners must achieve in order to be qualified for that job, so that tests of gunners' qualifications may be specified?	° The BIFV gunner performance objectives that are stated ° The format of the statements of BIFV gunner performance objectives ° The completeness of the performance objective statements ° The accuracy of the performance objective statements
3.2.1	Does the system produce exact definitions of what the gunner-learner are expected to achieve through training, so that tests of thoe achievements may be developed?	° The gunner-learner achievements that are defined ° The factors included in the definitions of gunner-learner achievements
3.2.1.1	Does the system produce correct specifications of the capabilities that gunner-learners are expected to achieve?	° Capabilities specified for achievement by BIFV gunner-learners
3.2.1.2	Does the system produce correct specifications of the actions that the gunner-learners are to execute to demonstrate the capabilities?	° Actions specified for execution by BIFV gunner-learners ° Observability of the actions
3.2.1.3	Does the system produce correct specifications of the objects that are to result from the execution of the actions by the gunner-learners?	° Objects specified as results of the action executions by BIFV gunner-learners ° Measurability of the objects
3.2.1.4	Does the system produce correct specifications of the circumstances under which the gunner-learners are to execute the actions to produce the objects?	° Circumstances specified for execution of the actions by BIFV gunner-learners
3.2.1.5	Does the system produce correct specifications of the tools and equipment BIFV gunner-learners are to use in executing the actions?	° Tools and equipment specified for use in the execution of the actions by BIFV gunner-learners
3.2.1.6	Does the system produce correct specifications of the constraints to be imposed upon the execution of the actions by the gunner-learners?	° Constraints specified for the execution of the actions by the BIFV gunner-learners
3.2.1.7	Does the system produce correct specifications of the criteria to be used to judge the adequacy of the objects resulting from the actions executed by the gunner-learners?	° Criteria specified as standards of adequacy for the objects resulting from the gunner-learners' actions

Figure 13. (Continued)

Subset No. 11: "Lesson Plans"

Issues		Attributes
3.3	Does the system produce adequate lesson plans outlining the content and procedures for all learning activities, including gunner-learner testing in conjunction with learning activities?	° Lesson plans prepared for BIFV gunnery learning activities ° Segments of the plans outlining gunner-learner testing ° Completeness of the testing segments ° Appropriateness of the testing segments to the learning activities
3.3.1	Does the system produce complete specifications of the instructional content for the learning activities, including the content of gunner-learner testing in conjunction with learning activities?	° BIFV gunnery learning activities for which content is specified in the lesson plans ° Content elements specified for each learning activity ° Content elements pertaining to testing
3.3.1.8	Does the system produce correct specifications of test problems and exercises in the instructional content for the BIFV gunnery learning activities?	° Test problems/exercises itemized in the lesson plan content
3.3.2	Does the system produce complete specifications of the instructional procedures for the learning activities, including the procedures for gunner-learner testing in conjunction with learning activities?	° BIFV gunnery learning activities for which procedures are specified in the lesson plans ° Procedural elements specified for each learning activity ° Procedural elements pertaining to testing
3.3.2.4	Does the system produce correct specifications of testing procedures in the instructional procedures for the BIFV gunnery learning activities?	° BIFV gunner-learner testing procedures itemized in the lesson plan procedures

Subset No. 12: "Training Documents"

Issues		Attributes
3.4	Does the system produce all necessary training documents, including in particular documents needed for BIFV gunner-learner testing?	° BIFV gunnery training documents prepared ° Documents and segments of documents that are relevant to gunner-learner testing ° Completeness of the testing documents/segments ° Accuracy of the testing documents/segments
3.4.2	Does the system produce documents providing all necessary guidance to BIFV gunnery training facilitators, including guidance for implementing gunner-learner testing?	° Documented guidance for BIFV gunnery training facilitators ° Guidance elements provided in the documentation ° Guidance elements pertaining to gunner-learner testing
3.4.2.2	Does the system produce complete sets of test specifications, addressing all applications and requirements for BIFV gunner-learner testing?	° Testing applications/requirements for which BIFV gunner-learner test specifications are documented ° Elements or aspects of testing included in the specifications

Figure 13. (Continued)

Subset No. 13: "Tests"

	Issues	Attributes
3.5	Does the system produce appropriate tests for administration to BIFV gunner-learners?	° BIFV gunner-learner tests prepared ° BIFV gunnery testing applications/requirements for which tests are prepared ° BIFV gunner behaviors for which the tests are prepared ° Relevance of the tests
3.5.1	Does the system produce appropriate tests for assessing the qualifications of candidate BIFV gunner-learners?	° Candidate gunner-learner qualifications for which tests are prepared ° Tests prepared for assessment of those qualifications
3.5.1.1	Do the candidate qualification tests provide adequate measures of the candidates' prerequisite abilities?	° Domains of learning addressed by the tests ° Actions elicited by the tests ° Objects intended to result from the actions elicited by the tests
3.5.1.2	Are appropriate procedures specified for applying the qualification tests to BIFV gunner candidates?	° Circumstances specified for the tests ° Tools and equipment specified for the tests ° Constraints specified for the tests ° Other aspects of applications procedures specified for the tests
3.5.1.3	Are appropriate standards for qualification as BIFV gunner specified for the candidate qualification tests?	° Specific standards specified for the qualification tests
3.5.2	Does the system produce appropriate tests for assessing requirements for tailoring the instruction to accepted BIFV gunner-learners?	° BIFV gunnery abilities for which tailoring tests are prepared ° Tests prepared for assessment of needs for tailoring instruction to fit gunner-learners' abilities
3.5.2.1	Do the tailoring tests provide adequate pre-training measures of accepted BIFV gunner-learners' abilities?	° Domains of learning addressed by the tests ° Actions elicited by the tests ° Objects intended to result from the actions elicited by the tests
3.5.2.2	Are appropriate procedures specified for applying the tailoring tests to accepted BIFV gunner-learners?	° Circumstances specified for the tests ° Tools and equipment specified for the tests ° Constraints specified for the tests ° Other aspects of applications procedures specified for the tests
3.5.2.3	Are appropriate standards for tailoring instruction specified for the BIFV gunnery tailoring tests?	° Specific standards specified for the tailoring tests
3.5.3	Does the system produce appropriate tests for measuring what gunner-learners have achieved as a result of BIFV gunnery training?	° BIFV gunnery abilities for which achievement tests are prepared ° Tests prepared for assessment of BIFV gunner-learners' achievements

Figure 13 (Continued)

Subset No. 13: (Cont'd)

Issues		Attributes
3.5.3.1	Do the achievement tests provide adequate post-training measures of BIFV gunner-learners' abilities?	° Domains of learning addressed by the tests ° Actions elicited by the tests ° Objects intended to result from the actions elicited by the tests
3.5.3.2	Are appropriate procedures specified for applying the achievement tests to BIFV gunner-learners?	° Circumstances specified for the tests ° Tools and equipment specified for the tests ° Constraints specified for the tests ° Other aspects of applications procedures specified for the tests
3.5.3.3	Are appropriate standards for BIFV gunner-learner achievement specified for the achievement tests?	° Specific standards specified for the achievement tests

Figure 13. (Continued)

Subset No. 14: "Training Trial Data"

	Issues	Attributes
3.6	Does the system produce all necessary and appropriate training trial data, including in particular data on BIFV gunner-learner testing?	° Training trials from which data are obtained ° Types or categories of data obtained ° The data obtained within each category ° Completeness of the data ° Accuracy of the data
3.6.1	Does the system produce sufficient data to provide justification for specific features of the BIFV gunnery instructional design?	° The data produced to provide justification for specific features of BIFV gunnery instructional design ° Gunner-learner testing conducted to help supply those data
3.6.1.1	Does the system produce appropriate entry test data derived from representative candidates for BIFV gunnery training?	° Representative candidates to whom BIFV gunnery entry testing is administered ° Entry level tests administered to the representatives ° The entry test data obtained
3.6.1.2	Does the system produce appropriate post-test data derived from representative current BIFV gunners?	° Representative current BIFV gunners to whom post-testing is administered ° Post-tests administered to the representatives ° The post-test data obtained
3.6.1.3	Does the system produce appropriate test item error analyses derived from tryout gunner-learners?	° The tryout gunner learners to whom test items are administered ° The test items administered in the tryouts ° The test item data obtained ° The analyses of error conducted on those data
3.6.2	Does the system produce sufficient data to demonstrate the validity and utility of BIFV gunnery training?	° The data produced to demonstrate the validity and utility of the BIFV gunnery training ° Gunner-learner testing conducted to help supply those data
3.6.2.1	Does the system produce appropriate test item error analyses derived from field test BIFV gunner-learners?	° The field test BIFV gunner-learners to whom test items are administered ° The test items administered in the field tests ° The test item data obtained ° The analyses of error conducted on those data

Figure 13. (Concluded)

required for detecting targets, or tracking, or shooting, etc. Unless the system can accurately define exactly what behaviors gunners must be able to manifest to accomplish effective gunnery operations, the system will not know what behaviors should be tested. If the training goals are loosely or ambiguously stated so that the required gunner behaviors are not clear, it is possible that the entire structure built upon the foundation of those goals will be inappropriate. That is, the gunnery performance objectives, the learning activities, the training documents, the testing specifications, and all other facets of the assembled instruction might be focused on a set of behaviors that are not quite the ones that BIFV gunners really need to perform. The people paying for the training design effort certainly would want some assurance, at the outset, that the system they are funding will be able to define the correct gunner behaviors.

But, how does one determine whether an ability is present before any processes are carried out and before any products are delivered? Obviously, one examines the people, plans and tools assembled for carrying out the processes and producing the products, and tries to determine whether they have what it takes to do the job right. In the case of the particular ability to state training goals in behaviorally referenced terms, the evaluator would examine the training design plans and perhaps speak with the training designers to ascertain:

- The behavioral terminology they intend to employ in their statements of BIFV gunnery training goals.

- The formats they intend to follow in preparing their statements of BIFV gunnery training goals.

These two attributes of Design subsystem potentiality will allow the evaluators to form reasonable judgments about the training designers' knowledge of behaviorally referenced goals, awareness of the importance of such goals for all facets of training development (including the specification of gunner-learner testing), provisions they are making for producing such goals, etc. In short, these two attributes provide the evaluator with something concrete with which to deal in his or her efforts to assess the system's ability to specify the proper kinds of training goals. After examining those attributes, an evaluator might report back something like the following to the keepers of the purse strings:

> "Look, I examined the proposal your training designers submitted, and I found nothing in it to indicate any recognition of the need to produce behaviorally referenced training goals. I spoke to the designers, and asked them to give me some examples of the kinds of goal statements they intended to develop. The examples they came up with were absolutely devoid of any behavioral terms. They simply weren't the kinds of statements that can lead to a proper analysis of learner bahavioral requirements. I asked them if they couldn't suggest a format for their goal statements that would help

make explicit the learners' intended behavioral achievements, and it was clear that they didn't really understand what I was seeking. I conclude that, as things now stand, your system can't insure that the goals will be stated in terms that imply the required gunner behaviors. I suggest that you delay starting the development of this training until you've either brought these designers up to speed, or until you've replaced them with some people who understand behaviorally referenced training."*

As a second example, consider the fifth issue in Subset No. 6, "Does the system accurately identify the physical skills that BIFV gunners must acquire to perform their tasks, so that appropriate tests of physical skills may be specified and developed?" This issue arises from a characteristics-level process, i.e., the analytic process used to identify the physical skills learners must acquire in order to serve as BIFV gunners. Clearly, tests of all required physical skills must be specified and administered as part of the gunner certification process. If the system's analysis is deficient, so that certain essential physical skills are not identified, or so that some irrelevant physical skills are mistakenly identified as essential, the testing specifications also will be deficient. As the design work progresses, the sponsors certainly would wish to know whether a thorough and accurate analysis of required physical skills is underway.

In order to assess that issue, the evaluator would look first at the analytic methods the training designers are using to identify required physical skills. Are those methods appropriate to the analytic needs at hand? Are all of the data required for application of those methods being obtained and used appropriately? Is there any fault to find with the way in which the training designers are applying those methods? As the analyses begin to produce results, the evaluator would examine the physical skills requirements identified. Are all of those skills really pertinent to BIFV gunnery operations? Are there any essential skills that haen't been identified in this analysis? Are there any skills that the designers have labelled "physical" that really are "mental?" Based on these and similar considerations, the evaluator can form a well reasoned judgment about the accuracy of the designers' approach to identifying physical skills requirements. That reasoned judgment will be based on measures applied to the two concrete attributes, viz., the analytic methods of skills identification and the identified skills themselves.

The evaluative issues thus lead to measurable attributes, and the attributes in turn lead to measures of performance and effectiveness. The question is: How does all this "leading" proceed? How does one discern the

*This sample "report" is purely hypothetical, and is intended only to illustrate how examination of concrete attributes could provide answers to the question posed in a particular evaluative issue. In no way should the reader infer that the authors of this report expect that the BIFV Task Force will produce poorly stated goals for gunnery training. The authors are much impressed with the experience, professionalism, and dedication of the Task Force members they have met, and have no doubt of the high quality of their work.

attributes in the issues, and how does one derive the measures from the attributes?

No precise or even preliminary guidelines, algorithms or heuristics for extracting attributes from issues have thus far been developed. A major purpose of this trial application of system performance taxonomization to evaluating BIFV Gunnery testing specifications is to generate an experiential base from which such guidelines can begin to be derived. But in very general terms, the analyst's thought process in searching for the attributes of a particular issue relevant to testing specification can be sketched this way:

> "Here is an issue that bears on how well the BIFV Gunnery Design Subsystem has (or can) define gunner testing specifications. I'm supposed to suggest a way of answering the question posed in this issue. First, I have to ask myself: which of the subsystem's people, resources/equipment, and procedures are involved in this issue? Next, what qualities or characteristics do those involved people, resources/equipment, and procedures have to possess, or produce in their work, if this issue is to be resolved affirmatively? Finally, what concrete, observable factors associated with those people, resources/equipment, procedures, or their work can I examine to determine whether those qualities or characteristics are present?"

The concrete, observable factors uncovered by the analyst are the attributes associated with the issue in question. The authors applied the mental process outlined above to each of the 119 performance-related issues deemed relevant to evaluation of BIFV gunner testing specifications. The outcome is the set of attributes presented along with the issues in Figure 13.

It is the authors' considered opinion that the attribute set documented in Figure 13 is a face-valid and comprehensive basis for evaluating the adequacy of the gunner-learner testing specifications. But that is only opinion, not proof. It is hoped that the reviewers of this report, including representatives of the BIFV Task Force and other specialists in training development and evaluation, will assess and critique the attribute set so that a much broader base of expertise and insight will be applied to the continuing development of APM procedures.

If the reader will accept the attribute set given in Figure 13 as being at least illustrative of the bases from which the evaluative issues can be addressed, attention can now turn to the derivation of measures from attributes. A measure, in most general terms, is a judgment or appraisal about the thing-being-measured. Measures applied to system attributes derived from various taxa of performance thus are judgments or appraisals of performance. Each such measure contributes some small bit of wisdom or insight about the total performance of the system-being-measured. Every measure "looks" at its attribute in its own unique way, and "weighs" the attribute on its own unique scales. Collectively, the measures are intended to

determine whether the attribute is "good enough" to meet the demands of the performance requirement from which it derives. Individually, each measure focuses on some particular aspect or dimension of "goodness."

Consider this example: the BIFV Gunnery Training Design subsystem must have the ability to insure that all BIFV gunnery performance objectives will be identified so that they may be addressed in gunner testing specifications. One attribute of the system's ability to do that is the scope of information available to it concerning the BIFV gunners' tasks. Gunnery performance objectives must be derived from the gunners' tasks. If the system's knowledge of the gunners' tasks is not "good enough," it will not have the ability to identify gunnery performance objectives accurately.

How does one measure whether a set of knowledge is "good enough." First, one specifies or states exactly what is known, i.e., the contents of the set of knowledge. Next, one identifies missing elements in the set of knowledge, i.e., facts or other information that should be known, but aren't. Finally, one identifies inaccuracies in the set of knowledge, i.e., supposed "facts" and other information that are not true. This is a roundabout way of saying simply that a person's knowledge of a given subject might be "bad" in any of three ways:

- the person might know nothing about the subject; or
- might know some things but not others; or
- might "know" some things wrong.

A combination of the last two is also possible.

In the specific context of the Design Subsystem's knowledge of the BIFV Gunner Tasks, the evaluator would need to determine, first, whether the subsystem knows anything about any of the tasks; second, whether some tasks are unknown to the subsystem; and, third, whether some of the "known" tasks are in fact not tasks required of BIFV gunners. Each of those determinations provides a separate judgment or appraisal of the goodness of the scope of information the Design Subsystem proposes to use as the basis for establishing BIFV gunnery performance objectives. That is, each is a separate measure of that one attribute of the system's potential for establishing objectives. It is to the credit of the BIFV Task Force that they have assembled a very comprehensive task data base which, in fact, helps to meet the Potentiality aspects analysis of this exercise.

Consider another example in the context of this same performance potentiality. Along with having good information about gunnery tasks, the Design Subsystem must have people who are qualified to do the job of establishing performance objectives. The staff's experience and qualifications thus constitute another attribute of the system's ability to produce well founded objectives. If their qualifications aren't "good enough," the system's ability to establish objectives also won't be good enough.

How does one measure the "goodness" of an individual's or team's qualifications for doing a particular job? When the job is relatively simple and of short duration, a candidate's qualifications sometimes can be measured by requesting him or her to actually do the work in question, on a sample basis. A typing test, for example, often is administered to candidates for a secretarial position. Then, actual job performance measures (e.g., words typed per minute, percentage of errors, etc.) can be applied to the sample work and used as job qualification measures. However, when the work is complex, cerebral and non-routine, this approach may not be practical. In such cases, clinical judgments usually are employed to appraise the candidate's qualifications. Subject-matter experts review resumes of the available candidates' experience and training relevant to the job to be filled, interview personal references named by the candidates, perhaps examine the products delivered by the candidates during previous assignments similar to the job to be filled, and maybe interview the candidates themselves to obtain greater insight concerning the skills and knowledge they could bring to the job. Each expert reviewer then produces an independent rating of each candidate, based on the reviewer's perception of the candidate's strengths and weaknesses. Such ratings often are placed on an interval or ordinal scale. Then, the expert reviewers meet as a group, report and explain their individual ratings, deliberate on and debate the issues raised concerning each candidate, and form a consensus rating of the qualifications of each.

This clinical approach can be applied to measure the Training Design staff's qualifications for establishing gunnery performance objectives. The appropriate measures would include the consensus rating of each individual proposed for assignment to the task of establishing objectives, and an overall consensus rating of the total proposed staff as a team for handling that task. Both types of consensus ratings should include or be augmented with detailed explanations of all identified personnel deficiencies bearing on the ability to establish objectives.

Referring next to Block 7 of the overall APM (Figure 1), it is relatively easy to suggest measures for any given attribute. Unfortunately, it is quite something else to devise a general procedure for doing so in all cases. Within the scope of this current study, measures have been suggested for all of the issues and attributes of four of the taxonomic subsets of Figure 13. These measures are arrayed in Figures 14 through 17. The authors believe that each suggested measure has something of value to say about the "goodness" or "badness" of the attribute to which it relates. The authors also believe that the measures suggested for each given attribute collectively say everything that is pertinent to the "goodness" or "badness" of that attribute. Obviously, both of these beliefs need to be subjected to the test of a careful, critical review by the readers of this report. It is quite possible, and probably very likely, that the measures hierarchies shown in Figures 14 through 17 will undergo significant revision after readers' comments are received. Subsequent to such revision, the measures hierarchies will provide a base from which we can begin to extract measures specification procedures.

Hierarchy Number 1: BIFV gunnery design subsystem potential for establishing performance objectives

(Note: Issue numbers refer to the taxa in Figure 7 from which they are derived.)

Issues

1.2 Ability to insure that all BIFV gunnery performance objectives will be identified so that they may be addressed in gunner testing specifications

Attributes	Measures
Scope of information available concerning BIFV gunners' tasks	A. BIFV gunners' required tasks that are known (listing and description of each such task) B. BIFV gunners' required tasks that are unknown to the Design Subsystem (listing of each) C. Tasks that actually are not required of BIFV gunners, but which mistakenly are classified as required by the Design Subsystem (listing and description)
Staff experience and qualifications in establishing performance objectives	D. Reviewers' cumulative ratings of each Design staff member's training, experience and previous performance in establishing performance objectives for training (using a specified point allocation system for training, experience, etc.) E. Reviewers' overall assessment of total Design staff's qualifications (based on specified method of accumulating individual members' ratings)
Planned approach to establishing BIFV gunnery performance objectives	F. Essential steps missing from the plans (listing and description of each such step) G. Inessential steps included in the plans (listing and description of each) H. Inconsistencies/deficiencies in the sequencing of steps in the plans I. Reviewers' cumulative ratings of the soundness/workability of the plans (using a specified point allocation system)
Resources allocated to establishing BIFV gunnery performance objectives	J. Percentage of required person-hours proposed for allocation to establishing objectives K. Percentage of required materials/goods proposed for allocation to establishing objectives L. Percentage of required support services proposed for allocation to establishing objectives M. Ratio of dollar value of total resources proposed for allocation to establishing objectives to dollar value of total resources actually required

1.2.1 Ability to insure that all things BIFV gunners will be able to do after training will be stated so that tests of all required abilities may be specified

Attributes	Measures
Elements or factors of gunner abilities intended to be stated	A. Essential elements of abilities intended to be included in the statements of BIFV gunner abilities (listing and description of each such type of element) B. Inessential elements intended to be included in the statements of BIFV gunner abilities (listing and description of each type) C. Essential elements of abilities not intended to be included in the statements of BIFV gunner abilities (listing and description of each type

Figure 14. Sample Measures Hierarchy Number 1

Intended formats for stating BIFV gunner abilities	D.	Reviewers' ratings of the degree to which the intended formats will enable clear expression of BIFV gunners' abilities
	E.	Specific deficiencies in the intended formats identified by reviewers (listing and description of each deficiency)
Plans for producing statements of intended abilities of BIFV gunners	F.	Essential steps missing from the plans for producing statements of abilities
	G.	Inessential/inappropriate steps included in the plans
	H.	Inconsistencies/deficiencies in the sequencing of steps in the plans
	I.	Deficiencies in the staff's abilities to carry out these particular plans
	J.	Deficiencies in the resources allocated to implementing these particular plans

1.2.1.1 **Ability to insure that definitions of the required gunner actions will be included in the statements of intended gunner abilities, so that the specified tests may address those actions**

Types of BIFV gunner performance actions intended to be defined	A.	Relevant types of actions not intended to be defined (description of each type)
	B.	Irrelevant types of actions intended to be defined (description of each type)
	C.	Reviewers' ratings of the observability of the types of actions intended to be defined
Plans for defining the actions required of BIFV gunners	D.	Essential steps missing from the plans for defining performance actions
	E.	Inessential steps included in the plans
	F.	Inconsistencies/deficiencies in the sequencing of steps in the plans
	G.	Deficiencies in the staff's abilities to carry out these particular plans
	H.	Deficiencies in the resources allocated to implementing these particular plans

1.2.1.2 **Ability to insure that definitions of the appropriate conditions under which the gunner actions are to be performed will be included in the statements of intended gunner abilities, so that the specified tests may reflect those conditions**

Elements or types of BIFV gunner performance conditions intended to be defined	A.	Relevant elements or types of conditions not intended to be defined (descriptions of each)
	B.	Irrelevant elements or types of conditions intended to be defined
Plans for defining the BIFV gunnery performance conditions	C.	Essential steps missing from the plans for defining performance conditions
	D.	Inessential/inappropriate steps included in the plans
	E.	Inconsistencies/deficiencies in the sequencing of steps in the plans
	F.	Deficiencies in the staff's abilities to carry out these particular plans
	G.	Deficiencies in the resources allocated to implementing these particular plans

Figure 14. (Continued)

1.2.1.3 **Ability to insure that definitions of the appropriate standards of acceptable performance of the gunner actions will be included in the statements of intended gunner abilities, so that the specified tests may incorporate those standards**

Elements or factors of BIFV gunner performance standards intended to be defined	A.	**Relevant elements or factors of performance standards not intended to be defined**
	B.	**Irrelevant elements or factors of performance standards intended to be defined**
Plans for defining the standards of BIFV gunnery performance	C.	**Essential steps missing from the plans for defining performance standards**
	D.	**Inessential/inappropriate steps included in the plans**
	E.	**Inconsistencies/deficiencies in the sequencing of steps in the plans**
	F.	**Deficiencies in the staff's abilities to carry out these particular plans**
	G.	**Deficiencies in the resources allocated to implementing these particular plans**

1.2.2 **Ability to insure that the identified BIFV gunnery performance ojbectives will be applied to provide a basis for objectively assessing gunners' performance**

Elements of the basis for assessment intended to be provided	A.	**Essential elements or segments of the basis for objective assessment of BIFV gunner performance intended to be provided (listing and description of each)**
	B.	**Inessential elements or segments of the basis intended to be provided (listing and description)**
	C.	**Essential elements or segments of the basis not intended to be provided (listing and description)**
Plans for providing a basis for objectively assessing BIFV gunners' performance	D.	**Essential steps missing from the plans for providing a basis for objective assessment**
	E.	**Inessential/inappropriate steps included in the plans**
	F.	**Inconsistencies/deficiencies in the sequencing of steps in the plans**
	G.	**Deficiencies in the staff's abilities to carry out these particular plans**
	H.	**Deficiencies in the resources allocated to implementing these particular plans**

1.2.2.1 **Ability to insure that appropriate pretest items addressing the performance objectives will be developed and included in the testing specifications**

Types of BIFV gunnery pretest items intended to be developed	A.	**Relevant types of pretest items not intended to be developed (listing and description)**
	B.	**Irrelevant/inappropriate types of pretest items intended to be developed (listing and description)**
Plans for developing BIFV gunnery pretest items	C.	**Essential steps missing from the plans for developing pretest items**
	D.	**Inessential/inappropriate steps included in the plans**
	E.	**Inconsistencies/deficiencies in the sequencing of steps in the plans**
	F.	**Deficiencies in the staff's abilities to carry out these particular plans**
	G.	**Deficiencies in the resources allocated to implementing these particular plans**

Figure 14. (Continued)

1.2.2.2 **Ability to insure that appropriate posttest items addressing the performance objectives will be developed and included in the testing specifications**

Types of BIFV gunnery posttest items intended to be developed	A. Relevant types of posttest items not intended to be developed (listing and description) B. Irrelevant/inappropriate types of posttest items intended to be developed (listing and description)
Plans for developing BIFV gunnery posttest items	C. Essential steps missing from the plans for developing posttest items D. Inessential/inappropriate steps included in the plans E. Inconsistencies/deficiencies in the sequencing of steps in the plans F. Deficiencies in the staff's abilities to carry out these particular plans G. Deficiencies in the resources allocated to implementing these particular plans

Figure 14. (Concluded)

Hierarchy Number 2: BIFV gunnery design subsystem process of analyzing tasks selected for training

(Note: Issue numbers refer to the taxa in Figure 7 from which they are derived.)

Issues

2.3 Conduct of analysis of BIFV gunner tasks, so that appropriate tests of those tasks may be specified

Attributes	Measures
Task analytic methods applied to the BIFV gunner tasks	A. Deviations between the methods actually applied and the methods specified in the plans for analyses (listing and description of each such deviation) B. Aspects or elements of the methods applied that are irrelevant to or inconsistent with the analytic purposes (listing and description of each) C. Aspects or elements missing from the methods applied that are essential for the analytic purposes (listing and description of each) D. Types of data needed for the methods that were not obtained (listing and description of each data deficiency)
The scope of the BIFV gunner task analyses conducted	E. Factors supposed to be determined from the task analyses that actually were not determined F. Factors irrelevant to the analytic purposes that were determined in the task analyses
Completeness of the BIFV gunner task analyses conducted	G. Relevant BIFV gunner tasks to which the analytic methods were not applied H. Factors missing from the analyses applied to other relevant BIFV gunner tasks
Accuracy of the BIFV gunner task analyses conducted	I. Inaccuracies in the input data obtained for application of the analaytic methods J. Specific misinterpretations of the analyzed data K. Specific aspects or elements of the analytic methods that were misapplied

2.3.2 Classification of BIFV gunner tasks in terms of the domains of learning they involve

Attributes	Measures
Methods employed to identify the domains of learning of the BIFV gunner tasks	A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the domains of learning involved in a task (listing and description) B. Aspects or elements missing from the methods employed that are essential for identifying the domains of learning (listing and description) C. Input data required for the methods that are missing or insufficient (listing and description)
The domains of learning identified for each BIFV gunner task	D. Domains identified as involved in a task that actually are not relevant to that task (listing and description of each such incident) E. Domains not identified as involved in a task that actually are involved in that task (listing and description of each such incident)

Figure 15. Sample Measures Hierarchy Number 2

2.3.2.1 **Identification of the knowledge that BIFV gunners must possess in order to perform their tasks, so that appropriate tests of knowledge may be specified and developed**

Methods employed to identify the knowledge requirements of BIFV gunner tasks	A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the knowledge required for performing a task (listing and description) B. Aspects or elements missing from the methods employed that are essential for identification of the knowledge required for performing a task (listing and description) C. Input data required for the methods that are missing or insufficient (listing and description)
The knowledge requirements identified for BIFV gunner tasks	D. Knowledge elements identified as required for a given task that actually are not needed for performance of that task (listing and description) E. Knowledge elements not identified as required for a given task that actually are needed for performance of that task (listing and description)

2.3.2.2 **Identification of the mental skills that BIFV gunners must possess in order to perform their tasks, so that appropriate tests of mental skills may be specified and developed**

Methods employed to identify the mental skill requirements of BIFV gunner tasks	A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the mental skills required for performing a task (listing and description) B. Aspects or elements missing from the methods employed that are essential for identification of the mental skills required for performing a task (listing and description) C. Input data required for the methods that are missing or insufficient (listing and description)
The mental skill requirements identified for BIFV gunner tasks	D. Mental skills identified as required for a given task that actually are not needed for performance of that task (listing and description) E. Mental skills not identified as required for a given task that actually are needed for performance of that task (listing and description

2.3.2.3 **Identification of the physical skills that BIFV gunners must possess in order to perform their tasks, so that appropriate tests of physical skills may be specified and developed**

Methods employed to identify the physical skill requirements of BIFV gunner tasks	A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the physical skills required for performing a task (listing and description) B. Aspects or elements missing from the methods employed that are essential for identification of the physical skills required for performing a task (listing and description) C. Input data required for the methods that are missing or insufficient (listing and description)
The physical skill requirements identified for BIFV gunner tasks	D. Physical skills identified as required for a given task that actually are not needed for performance of that task (listing and description) E. Physical skills not identified as required for a given task that actually are needed for performance of that task (listing and description)

Figure 15. (Continued)

2.3.2.4 **Identification of the attitudes that BIFV gunners must possess in order to perform their tasks, so that appropriate tests of attitudes may be specified and developed**

Methods employed to identify the attitudinal requirements of BIFV gunner tasks	A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the attitudes required for performing a task (listing and description) B. Aspects or elements missing from the methods employed that are essential for identification of the attitudes required for performing a task (listing and description) C. Input data required for the methods that are missing or insufficient (listing and description
The attitudinal requirements identified for BIFV gunner tasks	D. Attitudinal elements identified as required for a given task that actually are not needed for performance of that task (listing and description) E. Attitudinal elements not identified as required for a given task that actually are needed for performance of that task (listing and description)

2.3.3 **Identification of the conditions for learning the BIFV gunner tasks**

Methods employed to identify the conditions for learning the BIFV gunner tasks	A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the conditions for learning a task (listing and description of each such aspect) B. Aspects or elements missing from the methods employed that are essential for identifying the conditions for learning (listing and description C. Input data required for the methods that are missing or insufficient (listing and description)
Types of conditions for learning that are identified for each BIFV gunner task	D. Types of conditions for learning identified as associated with a task that actually are not relevant to that task (listing and description) E. Types of conditions for learning not identified as associated with a task that actually are relevant to that task (listing and description)

2.3.3.1 **Identification of the prerequisite knowledge that BIFV gunners should have in order to learn their tasks**

Methods employed to identify the prerequisite knowledge for BIFV gunner tasks	A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the knowledge prerequisites required for learning a task B. Aspects or elements missing from the methods employed that are essential for identification of the knowledge prerequisites required for learning a task C. Input data required for the methods that are missing or insufficient
Knowledge items identified as prerequisites for learning the BIFV gunner tasks	D. Knowledge items identified as prerequisites for learning a given task that actually are not needed or helpful for learning the task (listing and description) E. Knowledge items not identified as prerequisites for learning a given task that actually are essential for learning the task F. Knowledge items not identified as prerequisites for learning a given task that actually would facilitate learning the task, although not essential for learning

Figure 15. (Continued)

2.3.3.2 **Identification of the prerequisite mental skills that BIFV gunners should have in order to learn their tasks**

Methods employed to identify the prerequisite mental skills for BIFV gunner tasks

A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the mental skills prerequisites for learning a task

B. Aspects or elements missing from the methods employed that are essential for identification of the mental skills prerequisites for learning a task

C. Input data required for the methods that are missing or insufficient

Specific mental skills identified as prerequisites for learning the BIFV gunner tasks

D. Specific mental skills identified as prerequisites for learning a given task that actually are not needed or helpful for learning the task

E. Specific mental skills not identified as prerequisites for learning a given task that actually are essential for learning the task

F. Specific mental skills not identified as prerequisites for learning a given task that actually would facilitate learning the task, although not essential for learning

2.3.3.3 **Identification of the prerequisite physical skills that BIFV gunners should have in order to learn their tasks**

Methods employed to identify the prerequisite physical skills for BIFV gunner tasks

A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the physical skills prerequisites for learning a task

B. Aspects or elements missing from the methods employed that are essential for identification of the physical skills prerequisites for learning a task

C. Input data required for the methods that are missing or insufficient

Specific physical skills identified as prerequisites for learning the BIFV gunner tasks

D. Specific physical skills identified as prerequisites for learning a given task that actually are not needed or helpful for learning the task

E. Specific physical skills not identified as prerequisites for learning a given task that actually are essential for learning the task

F. Specific physical skills not identified as prerequisites for learning a given task that actually facilitate learning the task, although not essential for learning

2.3.3.4 **Identification of the prerequisite attitudes that BIFV gunners should have in order to learn their tasks**

Methods employed to identify the prerequisite attitudes for BIFV gunner tasks

A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the attitudinal prerequisites for learning a task

B. Aspects or elements missing from the methods employed that are essential for identification of the attitudinal prerequisites for learning a task

C. Input data required for the methods that are missing or insufficient

Specific attitudes identified as prerequisites for learning the BIFV gunner tasks

D. Specific attitudes identified as prerequisites for learning a given task that actually are not needed or helpful for learning the task

E. Specific attitudes not identified as prerequisites for learning a given task that actually are essential for learning the task

F. Specific attitudes not identified as prerequisites for learning a given task that actually facilitate learning the task, although not essential for learning

Figure 15. (Concluded)

Hierarchy Number 3: BIFV gunnery design subsystem product consisting of stated performance objectives

(Note: Issue numbers refer to the taxa in Figure 7 from which they are derived.)

Issues

3.2 Production of accurate and complete statements of BIFV gunner performance objectives, so that tests of gunners' qualifications may be specified

Attributes	Measures
The BIFV gunner performance objectives that are stated	A. Statements that define performance objectives that actually are not needed for BIFV gunnery (listing and description of each such statement) B. Performance objectives that actually are needed for BIFV gunnery that are not addressed in any of the statements produced (listing and description of each such objective)
The format of the statements of BIFV gunner performance objectives	C. Essential elements of performance objective statements not included in the format employed for stating BIFV performance objectives (listing and description of each missing element) D. Inessential/inappropriate elements in the format employed for stating BIFV performance objectives (listing and description of each such element)
The completeness of the statements of BIFV gunner performance objectives	E. Elements missing from the statements of particular BIFV performance objectives (tabulation of missing elements as a function of the stated objectives)
The accuracy of the statements of BIFV gunner performance objectives	F. BIFV performance objective statements that contain erroneous or inaccurate elements (tabulation of inaccurate elements as a function of the stated objectives) G. Description of the nature of the inaccuracies, for each stated objective

3.2.1 Production of exact definitions of the BIFV gunner-learners' expected achievements as a result of the training

Attributes	Measures
The BIFV gunner-learner achievements that are defined	A. Achievements defined that actually are not necessarily expected of BIFV gunner-learners during training (listing and description of each such achievement) B. Achievements not defined that actually are expected of BIFV gunner-learners during training (listing and description of each such achievement) C. Inexact or ambiguous elements in the definitions of BIFV gunner-learner achievements (listing and description) D. Inaccurate elements in the definitions of BIFV gunner-learner achievements (listing and description)
The factors included in the definitions of BIFV gunner-learner achievements	E. Factors included in the definitions that actually are irrelevant to the description of intended achievements of BIFV gunner-learners (listing and description) F. Factors missing from the definitions that actually are essential for describing intended achievements of BIFV gunner-learners (listing and description)

Figure 16. Sample Measures Hierarchy Number 3

	3.2.1.1	**Production of correct specifications of the capabilities that BIFV gunner-learners are expected to achieve**
Capabilities specified for achievement by BIFV gunner-learners	A.	Specified capabilities that actually are not relevant to the intended achievements of BIFV gunner-learners (listing and description)
	B.	Capabilities not specified that actually are essential to the intended achievements of BIFV gunner-learners (listing and description)
	3.2.1.2	**Production of correct specifications of the actions that BIFV gunner-learners are expected to execute in order to demonstrate each capability**
The actions specified for execution by BIFV gunner-learners	A.	Specified actions that actually do not necessarily demonstrate the intended capabilities (listing and description)
	B.	Actions not specified that actually would demonstrate the intended capabilities (listing and description)
The observability of the specified actions	C.	Reviewers' ratings of the inherent observability of the specified actions (Likert or numeric scale ratings)
	D.	Requirements for imposing artificial constraints on the gunner-learners' execution of the actions to enhance observability (listing and description)
	E.	Reviewers' ratings of the degree to which observation will impede or interfere with gunner-learners' execution of the actions (Likert or numeric scale ratings)
	3.2.1.3	**Production of correct specifications of the objects that are to result from the actions executed by the BIFV gunner-learners**
Objects specified as results of the actions to be executed by BIFV gunner-learners	A.	Specified objects that actually do not necessarily result from execution of the actions of BIFV gunner-learners (listing and description)
	B.	Objects not specified that actually would result from execution of the actions of BIFV gunner-learners (listing and description)
	C.	Specified attributes/features of the objects that do not actually indicate achievement of the intended gunner-learner capabilities (listing and description)
	D.	Non-specified attributes/features of the objects that actually are important indicators of achievement of the intended gunner-learner capabilities (listing and description)
Measurability of the specified objects	E.	Potential methods of direct measurement of the relevant attributes/features of the specified objects (listing and description of each method)
	F.	Potential methods of indirect/inferential measurement of the relevant attributes/features of the specified objects (listing and description of each method)
	G.	Probabilistic distribution of measurement error for each of the potential measurement methods

Figure 16. (Continued)

	3.2.1.4	**Production of correct specifications of the circumstances under which the BIFV gunner-learners are to execute the actions to produce the objects**
Circumstances specified for execution of the actions by BIFV gunner-learners	A.	Specified circumstantial factors/categories that actually do not apply to execution of the actions under realistic job conditions (listing and description of each such factor/category)
	B.	Non-specified circumstantial factors/categories that actually do apply to execution of the actions under realistic job conditions, and that might affect the execution of the actions (listing and description of each)
	C.	Deviations between the values, ranges, limits, etc., specified for circumstantial factors/categories and the values, ranges, limits, etc., that actually exist in those factors/categories under realistic job conditions (magnitude and direction of each such deviation)
	3.2.1.5	**Production of correct specifications of the tools and equipment to be used by BIFV gunner-learners in executing the actions**
Tools and equipment specified for use in executing the gunner-learners' actions	A.	Specified tools and equipment that actually would not be available or employed under realistic job conditions (listing and description)
	B.	Tools and equipment not specified that actually would be applicable and available under realistic job conditions (listing and description)
	3.2.1.6	**Production of correct specifications of the constraints to be imposed upon the execution of actions by BIFV gunner-learners**
Constraints specified for the execution of the gunner-learners' actions	A.	Specified constrained behaviors/activities that actually would not be constrained under realistic job conditions (listing and description)
	B.	Behaviors/activities not specified for constraint that actually would be constrained under realistic job conditions (listing and description)
	C.	Deviations between the degree of constraints specified and the degree of constraints that actually would exist under realistic job conditions (magnitude and direction of each such deviation)
	3.2.1.7	**Production of correct specifications of the criteria to be used to judge the adequacy of the objects resulting from the actions executed by the BIFV gunner-learners**
Criteria specified as standards of adequacy for the objects	A.	Deviations between the criteria specified and the standards actually required for adequate performance on the job (magnitude and direction of each such deviation)

Figure 16. (Concluded)

Hierarchy Number 4: BIFV gunnery design subsystem product consisting of tests

(Note: Issue numbers refer to the taxa in Figure 7 from which they are derived.)

Attributes	Measures
	Issues
	3.5 Production of appropriate tests for administration to BIFV gunner-learners
The BIFV gunner-learner tests that are prepared	A. Prepared tests that address each BIFV gunnery performance objective (listing and description as a function of each performance objective) B. Prepared tests that relate to no BIFV gunnery performance objective (listing and description of each such test)
BIFV gunnery testing application/requirements for which tests are prepared	C. Reviewers' ratings of the utility of each prepared test for each testing application/requirement (yes/no rating of each test for each application)
BIFV gunner behaviors for which tests are prepared	D. Listing of tests prepared for each behavior associated with each performance objective
Relevance of the tests	E. Deviations between the behaviors elicited by the tests and the behaviors that actually are to be addressed (listing and description of each such deviation)
	3.5.1 Production of appropriate tests for assessing the qualifications of candidate BIFV gunner-learners
Candidate gunner-learner qualifications for which tests are prepared	A. Relevant qualifications for which tests are prepared (listing and description of each such qualification) B. Relevant qualifications for which no tests are prepared (listing and description of each such qualification) C. Irrelevant "qualifications" for which tests are prepared (listing and description of each)
The tests prepared for assessment of the qualifications	D. Elements of each test that deviate from the qualifications actually required of acceptable gunner-learners (listing and description of each such deviating element) E. Probability that each test will be passed by candidates who actually do not possess the qualification being tested F. Probability that each test will be failed by candidates who actually do possess the qualification being tested G. Cumulative probability that an actually unqualified candidate will pass sufficient qualification tests to be accepted as a gunner-learner H. Cumulative probability that an actually qualified candidate will fail sufficient qualification tests to be rejected as a gunner-learner

Figure 17. Sample Measures Hierarchy Number 4

3.5.1.1 **Production of qualification tests that provide adequate measures of candidate BIFV gunner-learners' prerequisite abilities**

Domains of learning addressed by the tests

A. Qualification tests that can only be passed via application of a domain of learning other than the domain relevant to the qualification supposedly to be tested (listing and description of each such test)

B. Qualification tests that can also be passed via application of a domain of learning other than the domain relevant to the qualification supposedly to be tested (listing and description of each such test)

Actions elicited by the tests

C. Deviations between the actions elicited by the tests and the actions required to demonstrate each qualification (listing and description of each such deviation)

D. Probability that the execution of the elicited action implies the ability to execute the action required to demonstrate the qualification

E. Probability that a failure to execute the elicited action implies the inability to execute the action actually required to demonstrate the qualification

Objects intended to result from the actions elicited by the tests

F. Deviations between the objects intended to result from the test actions and the objects intended to result from the actually required actions (listing and description of each such deviation)

G. Probability that the production of the test object implies the ability to produce the actually required object

H. Probability that a failure to produce the test object implies the inability to produce the actually required object

3.5.1.2 **Production of appropriate procedures for applying the qualification tests to BIFV gunner-learner candidates**

Circumstances specified for the tests

A. Deviations between the circumstances specified for the tests and the circumstances under which the actual qualification abilities need to be applied during training (listing, description, magnitude and direction of each such deviation)

B. Probability that passing the test under the specified circumstances implies the candidate can apply the qualification ability during training

C. Probability that failing the test under the specified circumstances implies the candidate cannot apply the qualification ability during training

Tools and equipment specified for the tests

D. Deviations between the tools and equipment specified for the tests and the tools and equipment to be used by gunner-learners to apply the qualification abilities during training (listing and description of each such deviation)

E. Probability that passing the test using the specified tools and equipment implies the candidate can apply the qualification ability using the tools and equipment to be provided during training

F. Probability that failing the test using the specified tools and equipment implies the candidate cannot apply the qualification ability using the tools and equipment to be provided during training

Figure 17. (Continued)

Constraints specified for the tests	G.	Deviations between the constraints specified for the tests and the actual constraints governing the gunner-learners' application of the qualification abilities during training (listing and description of each such deviation)
	H.	Probability that passing the test under the specified constraints implies that the candidate can apply the qualification ability under the constraints that will exist during training
	I.	Probability that failing the test under the specified constraints implies that the candidate cannot apply the qualification ability under the constraints that will exist during training

3.5.1.3 **Production of appropriate qualification test standards for accepting candidate BIFV gunner-learners into training**

Standards specified for the qualification tests	A.	Deviations between the specified test standards and the actual standards of adequate performance of the qualification abilities during training (listing, description, magnitude and direction of each such deviation
	B.	Probability that satisfaction of the test standards implies that the candidate can satisfy the actual standards of adequate performance during training
	C.	Probability that failure to satisfy the test standards implies that the candidate cannot satisfy the actual standards of adequate performance during training

3.5.2 **Production of appropriate tests for assessing requirements for tailoring the instruction to accepted BIFV gunner-learners**

BIFV gunnery abilities for which tailoring tests are prepared	A.	Relevant gunnery abilities for which tests are prepared (listing and description of each such ability)
	B.	Relevant gunnery abilities for which no tests are prepared (listing and description of each such ability)
	C.	Irrelevant "abilities" for which tests are prepared (listing and description of each)
The tests prepared for assessment of the needs for tailoring instruction to fit learners' abilities	D.	Elements of each test that deviate from the abilities actually required of BIFV gunners (listing and description of each such deviating element)
	E.	Probability that each test will be passed by learners who actually do not possess the ability being tested
	F.	Probability that each test will be failed by learners who actually do possess the ability being tested
	G.	Cumulative probability that a learner's test performance will result in inappropriate tailoring of instruction for that learner

3.5.2.1 **Production of tailoring tests that provide adequate pre-training measures of accepted BIFV gunner-learners' abilities**

Domains of learning addressed by the tests	A.	Tailoring tests that can only be passed via application of a domain of learning other than the domain relevant to the ability supposedly to be tested (listing and description of each such test)
	B.	Tailoring tests that can also be passed via application of a domain of learning other than the domain relevant to the ability supposedly to be tested (listing and description of each such test)

Figure 17. (Continued)

Actions elicited by the tests	C.	Deviations between the actions elicited by the tests and the actions required to demonstrate each tested ability (listing and description of each such deviation)
	D.	Probability that the execution of the elicited action implies the learner can execute the action actually required to demonstrate the tested ability
	E.	Probability that a failure to execute the elicited action implies the learner cannot execute the action actually required to demonstrate the tested ability
Objects intended to result from the actions elicited by the tests	F.	Deviations between the objects intended to result from the test actions and the objects intended to result from the actually required actions (listing and description of each such deviation)
	G.	Probability that the production of the test object implies the ability to produce the actually required object
	H.	Probability that a failure to produce the test object implies the inability to produce the actually required object

3.5.2.2 **Production of appropriate procedures for applying the tailoring tests to BIFV gunner-learners**

Circumstances specified for the tests	A.	Deviations between the circumstances specified for the tests and the circumstances under which the actual gunnery abilities need to be applied on the job (listing, description, magnitude and direction of each such deviation)
	B.	Probability that passing the test under the specified circumstances implies the learner can apply the gunnery ability under realistic job circumstances
	C.	Probability that failing the test under the specified circumstances implies the learner cannot apply the gunnery ability under realistic job circumstances
Tools and equipment specified for the tests	D.	Deviations between the tools and equipment specified for the tests and the tools and equipment to be used by BIFV gunners to apply the tested abilities on the job (listing and description of each such deviation)
	E.	Probability that passing the test using the specified tools and equipment implies the learner can apply the gunnery ability using the tools and equipment to be provided on the job
	F.	Probability that failing the test using the specified tools and equipment implies the learner cannot apply the gunnery ability using the tools and equipment to be provided on the job
Constraints specified for the tests	G.	Deviations between the constraints specified for the tests and the actual constraints governing the BIFV gunners' application of the tested abilities on the job (listing and description of each such deviation)
	H.	Probability that passing the test under the specified constraints implies that the learner can apply the gunnery ability under the constraints that will exist on the job
	I.	Probability that failing the test under the specified constraints implies that the learner cannot apply the gunnery ability under the constraints that will exist on the job

Figure 17. (Continued)

3.5.2.3 **Production of appropriate tailoring test standards for tailoring the instruction to the BIFV gunner-learners' abilities**

Standards specified for the tailoring tests	A. Deviations between the specified test standards and the actual standards of adequate performance of the tested abilities on the job (listing, description, magnitude and direction of each such deviation) B. Probability that satisfaction of the test standards implies that the learner can satisfy the actual standards of adequate performance on the job C. Probability that failure to satisfy the test standards implies that the learner cannot satisfy the actual standards of adequate performance on the job

3.5.3 **Production of appropriate tests for assessing BIFV gunner-learners' achievements as a result of training**

Gunner-learner achievements for which tests are prepared	A. Relevant achievements for which tests are prepared (listing and description of each such achievement) B. Relevant achievements for which no tests are prepared (listing and description of each such achievement) C. Irrelevant "achievements" for which tests are prepared (listing and description of each)
The tests prepared for assessment of the BIFV gunner-learners' achievements	D. Elements of each test that deviate from the achievements actually required of certified BIFV gunners (listing and description of each such deviating element) E. Probability that each test will be passed by learners who actually do not possess the achievement being tested F. Probability that each test will be failed by learners who actually do possess the achievement being tested G. Cumulative probability that an actually unqualified learner will pass sufficient achievement tests to be certified as a gunner H. Cumulative probability that an actually qualified learner will fail sufficient achievement tests to be rejected as a gunner

3.5.3.1 **Production of achievement tests that provide adequate post-training measures of BIFV gunner-learners' abilities**

Domains of learning addressed by the tests	A. Achievement tests that can only be passed via application of a domain of learning other than the domain relevant to the ability supposedly to be tested (listing and description of each such test) B. Achievement tests that can also be passed via application of a domain of learning other than the domain relevant to the ability supposedly to be tested (listing and description of each such test)
Actions elicited by the tests	C. Deviations between the actions elicited by the tests and the actions required to demonstrate each achievement (listing and description of each such deviation) D. Probability that the execution of the elicited action implies the ability to execute the action actually required to demonstrate the achievement E. Probability that a failure to execute the elicited action implies the inability to execute the action actually required to demonstrate the achievement

Figure 17. (Continued)

Objects intended to result from the actions elicited by the tests	F. Deviations between the objects intended to result from the test actions and the objects intended to result from the actually required actions (listing and description of each such deviation) G. Probability that the production of the test object implies the ability to produce the actually required object H. Probability that a failure to produce the test object implies the inability to produce the actually required object

3.5.3.2 **Production of appropriate procedures for applying the achievement tests to BIFV gunner-learners**

Circumstances specified for the tests	A. Deviations between the circumstances specified for the tests and the circumstances under which the actual tested abilities need to be applied on the job (listing, description, magnitude and direction of each such deviation) B. Probability that passing the test under the specified circumstances implies the learner can apply the gunnery ability under realistic job circumstances C. Probability that failing the test under the specified circumstances implies the learner cannot apply the gunnery ability under realistic job circumstances
Tools and equipment specified for the tests	D. Deviations between the tools and equipment specified for the tests and the tools and equipment to be used by BIFV gunners to apply the tested abilities on the job (listing and description of each such deviation) E. Probability that passing the test using the specified tools and equipment implies the learner can apply the gunnery ability using the tools and equipment actually available on the job F. Probability that failing the test using the specified tools and equipment implies the learner cannot apply the gunnery ability using the tools and equipment actually available on the job
Constraints specified for the tests	G. Deviations between the constraints specified for the tests and the actual constraints governing the BIFV gunners' application of the tested abilities on the job (listing and description of each such deviation) H. Probability that passing the test under the specified constraints implies that the learner can apply the gunnery ability under the constraints that will exist on the job I. Probability that failing the test under the specified constraints implies that the learner cannot apply the gunnery ability under the constraints that will exist on the job

3.5.3.3 **Production of appropriate achievement test standards for certifying learners as BIFV gunners**

Standards specified for the achievement tests	A. Deviations between the specified test standards and the actual standards of adequate performance of the tested abilities on the job (listing, description, magnitude and direction of each such deviation B. Probability that satisfaction of the test standards implies that the learner can satisfy the actual standards of adequate performance on the job C. Probability that failure to satisfy the test standards implies that the learner cannot satisfy the actual standards of adequate performance on the job

Figure 17. (Concluded)

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5. <u>Concluding Remarks Concerning the Trial Application to Measurement of Training System Performance/Effectiveness</u>

Clearly, much remains unproven as we conclude this trial application. Its final product is merely a partial set of measures for assessing one very narrow aspect of the work required of the BIFV Gunnery Training Design Subsystem. Most glaringly, those measures are untried. We have not attempted actually to apply them, nor even to verify that the information needed to generate them can be obtained. Those measures, moreover, derive from attributes that also are unproven. No attempt has even been made to demonstrate convincingly that the attributes stated really constitute all of the factors pertinent to each evaluative issue, and only those factors.

What, then, <u>has</u> been demonstrated? If nothing else, a set of measures has been produced that definitely is issues-oriented. We have been able to proceed from a framework of basic performance requirements to a statement of exactly what requirements apply to a given measurement application. We have shown that such requirements can be expressed in terms that permit concrete, tractable attributes to be defined. None of the attributes stems from any particular approach to training system design. All of the attributes strictly derive from the performance requirements that are common to all such designs. This is a critical point: it demonstrates that the APM at least is rooted firmly in valid measurement issues. Too often, evaluations of new systems are clouded by irrelevant and unfair comparisons with older <u>design</u> concepts. The basic question of whether the new system does what it is supposed to do sometimes is overlooked because the evaluators actually measure how the new system "looks" in comparison to older models. Conclusions based on such evaluations typically boil down to this: "The system is no good because we've never done it this way before." That design-oriented philosophy of measurement suppresses technological breakthroughs. In the training sphere, it prevents modern and effective methods of work site, learner-tailored instruction from playing their appropriate role in the total learning environment and it masks the relative ineffectiveness of the traditional, institutonal methods of training. The authors consider it to be a major step forward to have shown that a training measurement scheme can be kept free of artificial judgments of design. Use of the APM has forced a rather complete taxonomy of performance requirements to be considered in a measurement application; more complete than a typical, less-structured analysis would provide.

Finally, it has been shown that measures <u>can</u> be identified for these performance-oriented attributes. Much remains to be done to develop guidelines for insuring that the best such measures always are identified. But the first step, at least, has been taken in that direction.

The next section of this report explores the utility of the APM for specifying how training system performance requirements can be met.

D. The APM for Development of Training System Requirements

The purpose of this section is to illustrate how training system performance taxa identified for any particular human-machine system can be applied to produce training system requirements for that particular system. The approach presented proceeds through the following steps:

(1) Define precisely the system of interest.
(For this example, the system of interest will be one training subsystem, i.e., the training design subsystem of an Army training system under consideration for further development/procurement.)

(2) Determine and identify training system performance requirements.
(This example will illustrate the procedures to be used in translating general training design performance taxa for any system into training system requirements for a system of interest.)

(3) Present an approach on how these training subsystem design requirements may be satisfied by the training design subsystem.
(Here examples are presented to illustrate how the training design subsystem plans its approach to satisfy the training design requirements.)

1. The System of Interest: The Design Subsystem of U.S. Army Handgun Training

Currently, several U.S. joint military services study groups have been formed to determine the need and feasibility of adopting a standardized 9mm handgun as a replacement for more than 25 different makes, models and types of handguns currently in the U.S. services inventory (Air Force, Army, Navy, Marines and Coast Guard). A Joint Service Small Arms Training Task Force (JSSATTF) has recommended that all U.S. armed services adopt a single family of 9 mm handguns; however, to date no final conclusions have been made. The U.S. Army currently requires the largest number of handguns (approximately 331,000) as a personal defensive weapon for such Army personnel as certain front-line officers, non-commissioned officers, operators of crew-served weapons, aircrews, drivers, equipment operators, rear echelon personnel, etc.

In the context of this application an assumption is made that the JSSATTF would assign the overall responsibility for training development to the Army. Since the new handgun is considered to be in the family of Infantry weapons, the U.S. Army Infantry School would develop the curricula for the Army 9mm Handgun Training System (AHTS). The AHTS is a training system that incorporates the six general training subsystems within itself; these are the Command, Design, Enabling, Emplacement, Logistics and Delivery subsystems. Figure 18 depicts the network of other systems that interact with the AHTS. These include:

- The system known as the U.S. Army Infantry School. At this stage of training development, the AHTS would be wholly contained within the Infantry School, which would be considered a suprasystem to the system of interest.

- JSSATTF. The Task Force is comprised of highly qualified representatives of each of the U.S. military services. The JSSATTF will determine likely handgun users and uses. The JSSATTF will develop the training system requirements for the AHTS. The JSSATTF is a suprasystem to the system of interest.

- U.S. military services. These macrosystems impact on training system requirements through the JSSATTF. The AHTS has to satisfy their training system requirements. Eventually, each of these services will require its own service-specific handgun training system. They will, in fact, have a network of training systems which will be somewhat analogous to the AHTS, i.e., various MOS training systems, unit training systems, school training systems, etc.

- Various U.S. Army Branch School Training Systems (Armor, Artillery, Signal, etc.). The AHTS will be integrated eventually into these training systems. AHTS training must be compatible with these training systems. These systems therefore must be considered as collateral systems to the system of interest and the AHTS.

- Various U.S. Army Training Systems. The personnel who will be assigned the new handgun function within a specific military occupational specialty (MOS). The AHTS must be compatible with each of these training systems. These personnel will be the AHTS learners. The systems are collateral to the AHTS.

- Various types of U.S. Army unit training systems (mechanized infantry, self-propelled artillery, heavy-construction engineer, etc.). The AHTS learners/users are within these types of training systems as depicted by their Tables of Organizational Equipment (TOE). The AHTS must be compatible with the other on-going training the AHTS learners have or will have received. These systems are collateral to the AHTS.

- The 9mm handgun itself with its characteristics is an essential collateral system to the AHTS.

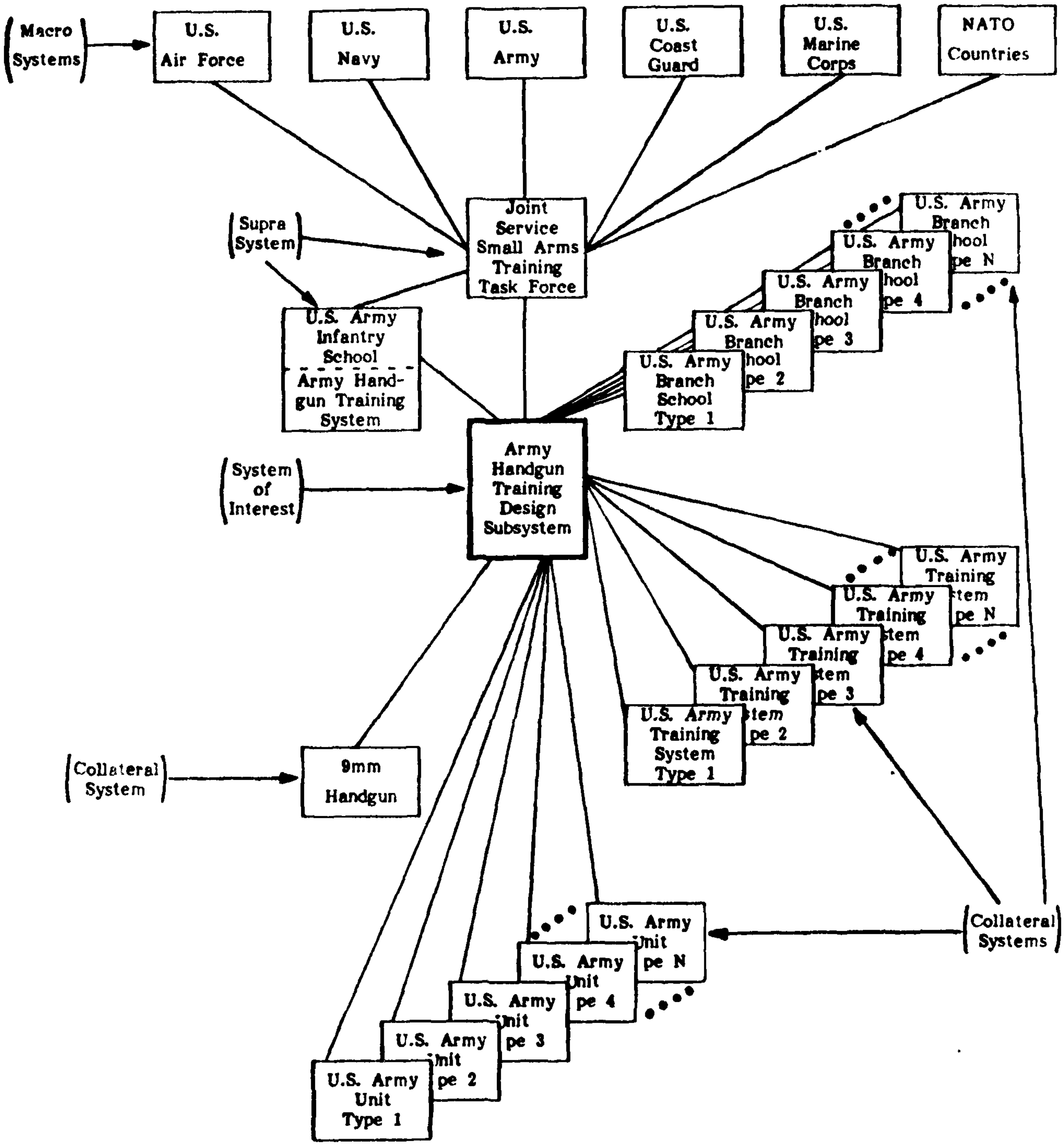


Figure 18. Major Systems Interacting with the Army Handgun Training Design Subsystem

The Army Handgun Training Design Subsystem (AHTDS), a subsystem of the AHTS, is the system of interest. The AHTDS is given the training requirements identified by the JSSATTF and the AHTS Command subsystem and translates these requirements into specific training plans/specifications. The AHTDS is the curriculum developer. As such, the AHTDS determines the learner behaviors that are to be affected during learning, and specifies the sensory activities to be conducted to achieve the effects. The AHTDS produces all of the learning procedures and resource specifications and some of the material required by the AHT Delivery subsystem. The AHTDS makes basic decisions with regard to learning facilitators, facilities, material and equipment needed to implement the learning activities.

2. Determining Training System Performance Requirements

At the conceptual stages of a particular training system's development the suprasystem (which has direct administrative control of the training system), has the overall responsibility to develop training system performance requirements for each of the training system's six subsystems (Command, Design, Enabling, Emplacement, Logistics and Delivery). For this application, the JSSATTF is the suprasystem and therefore the training administrator and, as such, exercises administrative control over the total training system, i.e., the AHTS. The JSSATTF must specify the performance requirements in such detail as to insure that the total training system achieves its purposes of learning and helping-to-learn.

This application focuses on the Training Design Subsystem of the AHTS. In developing training performance requirements, the JSSATTF can apply the general design subsystem performance taxa as shown in Figure 7. Each taxon is a performance-oriented Design subsystem requirement. Therefore, in developing the Design subsystem training performance requirements, the complete taxa shown in Figure 7 applies. The taxa constitute a performance checklist of capabilities, procedures and products that the Design subsystem must plan for in meeting the training systems purposes.

The JSSATTF must translate the general Design subsystem training performance requirements specifically for the AHTS. At this stage of system development, the JSSATTF knows who the learners are, (i.e., the Army handgun users) and, generally, for what purposes the Army handgun is to be used, (i.e., the jobs for which the handgun is to be employed).

As an aid in writing the AHT Design Subsystem (AHTDS) training requirements, it is helpful to organize the performance taxa identified in Figure 7 into logically associated groups within a particular contextual aspect of system performance, e.g., Performance Potentialities. A specific objectives-level taxon should be followed by the first functional purposes-level taxon; the first functional purposes-level taxon should then be followed by its supporting characteristics-level taxa. The process is continued for that objective level taxon until all of the functional purposes-level taxa and their supporting

characteristics-level taxa have been tied together explicitly. For example, to prepare the AHTDS training performance requirements, the taxa for Performance Potentiality 1.4 shown in Figure 7 could be organized as follows:

Objectives Level	1.4	Defining training content
Functional Purposes Level	1.4.1	Selecting stimuli for each objective
Characteristics Level	1.4.1.1	Defining propositions, names, facts, etc., relevant to information objectives
	1.4.1.2	Defining concepts, rules, algorithms, etc., relevant to mental skills objectives
	1.4.1.3	Defining movements, timings, actions, etc., relevant to physical skills objectives
	1.4.1.4	Defining values, choices, etc., relevant to attitude objectives
Functional Purposes Level	1.4.2	Selecting instructional setting for each objective
Characteristics Level	1.4.2.1	Assessing applicability of Job Performance Aids (JPA's)
	1.4.2.2	Assessing applicability of Self-Teaching Exportable Packages (STEP's)
	1.4.2.3	Assessing applicability of Formal On-the-Job Training (FOJT)
	1.4.2.4	Assessing applicability of Installation Support School (ISS)
	1.4.2.5	Assessing applicability of Resident School
	Etc.	

Use of this or some other suitable scheme greatly facilitates organization of the performance taxa needed to generate a particular training subsystem's performance requirements.

The next step is to translate the organized general performance taxa into subsystem training performance requirements for a specific training system. Again for this application, training performance requirements are for the AHTDS. Each requirement must address the specific subsystem which must perform the work. Each of the contextual stage performance taxa systematically will identify the performance requirements which must be addressed by the training subsystem. Generally, the contextual stage requirements for the AHTDS will state the following:

(1) AHTDS Performance Potentialities Requirements
These requirements state the capabilities/potentialities the AHTDS must address.

(2) AHTDS Performance Processes Requirements
These requirements state the processes/procedures the AHTDS must address.

(3) AHTDS Performance Products Requirements
The requirements state the products the AHTDS must address.

To continue the above example, the performance taxa for Performance Potentiality 1.4 and Functional Purpose 1.4.1 could be restated into AHTDS training performance requirements as follows:

Objectives Level	1.4	The Handgun Training Design Subsystem must possess the ability to define the handgun training content required to achieve the user's performance objectives
Functional Purposes Level	1.4.1	Given a list of handgun users and uses, and given the defined training goals and analyzed performance objectives, the Design Subsystem must be able to select stimuli for each performance objective relevant to the domains of learning
Characteristics Level	1.4.1.1	The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define propositions, facts, names, etc., that are relevant to information-type objectives

1.4.1.2 The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define concepts, rules, algorithms, etc., relevant to mental skills objectives

1.4.1.3 The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define handgun user/uses movements, actions, timings, etc., for relevant physical skill objectives

1.4.1.4 The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define handgun user/uses choices, values, etc., relevant to attitude objectives

It should be noted by the reader that each requirement in the above example is specific to the AHTDS. Further, since these are Performance Potentialities Requirements, they are stated in terms of "abilities" or "capabilities" which the AHDTS must demonstrate that it possesses to effectively respond to the requirement. Similarly, the Performance Process Requirements are stated in terms which require the AHTDS to demonstrate its ability to effectively plan an approach to satisfy these requirements. With regard to Performance Product Requirements, these are stated in terms which require the AHTDS to demonstrate its ability to plan how it will deliver or produce the specified product requirements. Figure 19 is a sample of detailed training performance requirements specific to the AHTDS. Figures B1 through B6 present all of the training performance requirements for the basic potentialities specific to the AHTDS.

3. An Approach to Developing Training System Design Specifications

The general training system performance taxa shown in Figures 7 and 8 constitute the performance requirements faced by every Design Subsystem and Enabling Subsystem, respectively. Figures 19 and B1-B6 in Appendix B present Design Subsystem taxa in terminology that is specific to the Army Handgun Training System. Those figures, too, deal in performance requirements. In earlier segments of this report, the point was emphasized that system evaluation should address itself solely to issues stemming from

Performance Potentiality Hierarchy Number 1: The capability of identifying training goals and priorities

1.1
The Handgun Training Design Subsystem must possess the ability to identify training goals and priorities for all intended military users and uses of the handgun.

1.1.1
Given a list of handgun users and uses, the Design Subsystem must be able to define the scope of learning needed for each handgun user/use in terms of the knowledge, skills, and attitudes required.

1.1.1.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify, for each handgun user/use, exactly what the user must know; exactly what skills the user must possess; and exactly what attitudes the user must manifest.

1.1.1.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to analyze the identified knowledge, skills, and attitudes to determine their suitability for training.

1.1.2
Given a list of handgun users and uses, the Design Subsystem must be able to define what each user ultimately will be able to do with the handgun, in training goal terms.

1.1.2.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define the necessary levels of performance achievements that each handgun user must manifest in order to apply the handgun to its intended uses.

1.1.2.2
The Handgun Training Design Subsystem must demonstrate that it is able to determine correctly the pre-training levels of the relevant performance achievements possessed by members of the intended handgun user populations.

1.1.2.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to discern correctly the discrepancies existing between current and required levels of relevant performance achievements within the intended handgun user populations.

1.1.3
Given a list of handgun users and uses, and given the training goals defined for each user/use, the Design Subsystem must be able to identify the relative importance of each defined goal.

1.1.3.1
The Handgun Training Design Subsystem must demonstrate that it has the ability to formulate assessments of training goal importance.

1.1.3.2
The Handgun Training Design Subsystem must demonstrate that it can devise or select a suitable scheme for ranking the relative importance of its training goals.

1.1.4
Given a list of handgun users and uses, and given the training goals defined for each user/use, the Design Subsystem must be able to express the goals in behaviorally oriented terms to establish a basis for identifying handgun user performance objectives.

1.1.4.1
The Handgun Training Design Subsystem must demonstrate that it can devise or select a suitable taxonomy of goals/objectives to be used to classify its intended training outcomes.

1.1.4.2
The Handgun Training Design Subsystem must demonstrate that it is capable of stating its goals in terms that permit the necessary user behaviors to be identified.

Figure 19. Army Handgun Training Design Subsystem Performance Requirements Basic Potentialities Needed: Hierarchy Number 1

performance requirements. The evaluator's proper frame of mind can be illustrated as follows: "I don't care what it looks like, and I don't care why it looks that way; I only want to know if it performs the way it is supposed to perform." The evaluator needs to have that point of view in order to insure that the evaluation process and its conclusions are not contaminated by irrelevant considerations of design. The evaluator cannot allow himself or herself to jump to the conclusion that a system is no good simply because it "looks" different from its predecessors. Neither can the evaluator automatically assume that the system is good simply because it embodies radically new design concepts. The evaluator needs to preserve a strict disinterest in issues of design.

Somebody, however, does have to worry about what the system should "look like." Somebody has to build the system to satisfy its performance requirements. If it isn't built properly, it surely won't meet those requirements. And the proper building of anything has to start with the proper design.

The specification of a training system design is nothing more nor less than the plan for building the training system to satisfy its performance requirements. The design specification thus must evolve from those requirements, i.e., from the same taxa of potentialities, processes, and products from which the evaluator extracts the measures of system performance and effectiveness. The system designer looks at each taxon and asks, "How can I see to it that the system will have all of these potentialities? How should I arrange for the system to carry out all of these required processes? How can I best insure that it will deliver all of these required products?" Of course, the designer must come up with answers to these questions that are compatible with the taxa of Environment and Constraints under which the system must operate. But the questions themselves are rooted in the taxa of performance.

Our question is: How does the designer answer these questions? How does a design specification evolve from the system performance requirements?

The first step in this process is identical to the first step in the evaluation process: one examines each taxon to identify its associated system attributes. Here again, an attribute is some concrete element of the system, something that can be seen, examined, submitted to analysis, etc. It is, therefore, something for which concrete plans may be formulated.

The Design attributes associated with a particular taxon are any and all features of the system's people, equipment, and procedures that may affect satisfaction of the performance requirement represented by that taxon. The features of relevance, of course, may vary from one taxon to another. The relevant features of people associated with one taxon, for example, might include their visual acuity, their physical strength, their height, their resistance to motion sickness, etc. That is, the nature of the particular performance requirement would be such that the system would need to have some operators possessing those physical attributes if the system is to be able to meet that requirement. Analysis of some other taxon might disclose that

people are needed who possess a certain degree of knowledge about some particular subject, who can apply certain mental skills, and who manifest certain attitudes concerning particular topics. The nature of that particular performance requirement would demand that it be addressed by people who had those specific intellectual and affective attributes.

The system designer's job thus begins with the identification of all of the features of people, equipment, and procedures that relate to the satisfaction of all of the performance requirements that the system-to-be-built will face. Then, the designer must prepare plans or statements showing exactly how he or she will see to it that all of those features are included in the system.

To illustrate, recall that one performance requirement that a training system designer faces is job analysis. That is an objectives-level taxon of process. The designer knows that the plans for building any training system must include a provision to "analyze the job for which training is to be developed." The problem is that the form or method of job analysis that may work well for one training system may not be most appropriate or even workable for another training system. A designer who doesn't pause to consider the attributes of the specific system to be built might simply select a job analysis plan "off the shelf," dust it off and incorporate it into the system specification. That plan might place heavy emphasis on the conduct of observations of actual performances of the job to be analyzed. That is certainly a traditional and often effective approach to job analysis. But in the case of a brand new job, never before performed, it may be totally inappropriate to rely on observational methods of job analysis: there simply wouldn't be any job performers to observe. A study of the attributes of the data available for the job analysis would disclose that other methods would be required, e.g., methods relying on review of the specifications for the newly developed job, interview with the designers of the new job, etc. Similarly, the training system designer would determine that the people who will be assigned to perform the job analysis would need to be skilled in interviewing techniques and "paper-and-pencil" analytic methods, rather than simply being well trained observers.

Figure 20 presents a sample of the design specification that might be written in response to the performance requirements of the Army Handgun Training System. The selected sample addresses the first hierarchy of performance potentialities of the Design Subsystem, i.e., the objectives, functional purposes, and characteristics taxa associated with the potential for identifying training goals and priorities. Appendix B provides additional samples of design specifications for the process and products aspects of the AHTDS.

Preparation of a design specification such as that shown in Figure 20 "merely" is a matter of deciding how best to insure that all appropriate features of people, equipment, and procedures are built into the developing system. Of course, a good deal of design talent is needed to do "merely" that. Good system designers are paid well, and deserve to be. Deciding how a set of diverse performance requirements can be met most effectively is never

Potentiality Performance Requirement Number 1:
The capability of identifying training goals and priorities.

(1.1)

The Army Handgun Training Design Subsystem Task Force recognized that a solid capability for identifying its training goals and establishing their relative importance must be brought to bear on the training design effort. The Task Force has assembled a highly qualified team, including representatives of all user services whose members collectively possess skills and experience in such relevant disciplines as task analysis, operations research, human factors engineering, and training program design. The members of the team will have access to all relevant documentation on the handgun, and will have ample opportunity to interview current and prospective users of the handgun, including some Allied military personnel. The team will develop separate lists of training goals and priorities for each service's intended user populations, as well as a master, all-services list. Names and relevant experience of the team members are given in Section ** of this specification.

(1.1.1, 1.1.2, 1.1.3, 1.1.4)

The Task Force has determined that the principal use of the handgun will be as a short-term personal defensive weapon. Users who will so employ the handgun include front line officers and non-commissioned officers; operators of crew-served weapons; pilots; drivers; various equipment operators and technicians; and, certain rear echelon personnel. A secondary use of the handgun will be as a law enforcement offensive and defensive weapon, to be used by military police. The charter of the task Force explicitly excludes the latter use from the scope of the training design requirements. Accordingly, members of the team will focus exclusively on the handgun's use as a personal defensive weapon. They will analyze a representative set of close-contact-combat reports from World War II and the Korean and Viet Nam conflicts to develop scenarios in which the handgun user tasks can be identified. Appropriate methods of task analysis will be applied to determine handgun user usage requirements in those scenarios, and to identify the knowledge, skills, and affective characteristics needed to satisfy those usage requirements. Using the Delphi and/or other suitable rating techniques, the team members will determine the criticality of the knowledge, skill, and attitude ingredients. This will be coupled with a review of the intended user populations to assess the current status of the knowledge, skills, and attitudes. The critical deficiencies thus identified will serve as the basis for identifying the training goals. The

Figure 20. Sample Design Specifications for the AHTDS
(Potentialities Aspect)

[Appendix B provides sample design specifications, for the Processes and Products Aspects of the AHTDS]

goals will be evaluated in terms of their relative importance; this step will solicit input from representatives of the intended user populations as well as from the team members individual and collective judgments. The team members will apply their human factors and training development expertise to insure that the goals express the quantifiable actions and conditions required for effective use of the handgun.

(1.1.1.1, 1.1.1.2)

Analysis of the knowledge, skills, and attitudes required for effective use of the handgun for personal defense will proceed in accordance with the information-decision-action attribute model, described in detail in Section ** of this specification. Briefly, this model calls for analysis of the sequential operations required of a task under study. The operations are examined at steadily increasing levels of detail until all human actions, movements, queries, decisions, etc., have been identified, together with their stimuli and outputs. Increasingly detailed formulations of the human knowledge and skill requirements emerge from this analysis, and operator attributes and attitudinal characteristics can be inferred from those requirements. The team will evaluate each identified requirement to determine, first, the need for training to insure that it will be satisfied by intended handgun users; second, the expected amount and cost of training that would be needed to insure satisfaction of the requirement; and, third, the practicality of providing that training. Any knowledge, skill, attribute, or attitudinal requirement not deemed suitable for training will be established as prerequisites for candidate handgun learners.

(1.1.2.1, 1.1.2.2, 1.1.2.3)

The team sill examine the required knowledge, skills, and attitudes in the context of the representative scenarios. The purpose will be to assess the achievement standards required for effective use of the handgun as a personal defense weapon. Factors such as accuracy, repeatability, duration, etc., of knowledge/skill performance will be varied to determine their impact on the scenarios' outcomes. Attitudinal and attribute characteristics also will be varied and assessed. Minimum standards of achievement then will be postulated. Representatives of the intended user populations will be examined to determine their current levels of achievement. These representatives will form a sample of users stratified by characteristics relevant to handgun usage, e.g., such characteristics as the user's job assignment, anthropometric characteristics, GS scores, and other relevant factors that may have emerged from the analysis. Findings will be compared with the identified minimum achievement standards, to discern achievement discrepancies that are to be addressed in training. This will produce o refinement of the training needs analysis discussed above.

Figure 20. (Continued)

(1.1.3.1, 1.1.3.2)

The training requirements emerging from the team's analysis assessed as to relative importance. Team members will produce individual, independent ratings for the training needs identified for their own services' intended users. These individual ratings will be submitted anonymously, and will be reviewed, discussed, and critiqued in a round-table format. That will be done first on an individual service basis and finally collectively for all users/uses. Consensus sets of needs importance ratings will emerge from this activity. Finally, the needs list will be reviewed and rated by the representative intended users and by selected Allied current handgun users, for validation and refinement.

(1.1.4.1, 1.1.4.2)

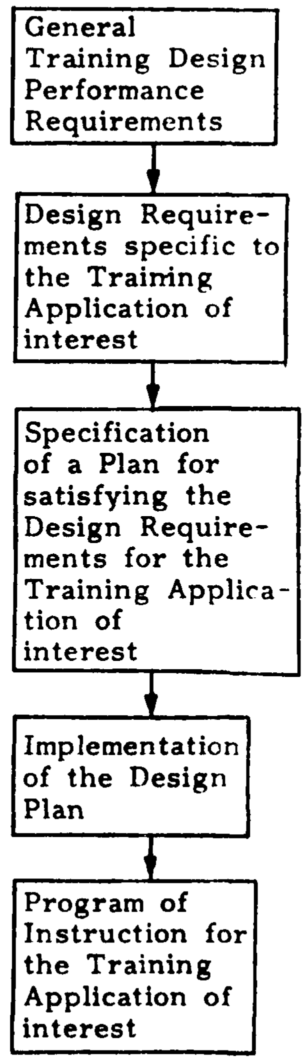
Each selected training goal will be classified as to its relevant domain of learning. The tripartite taxonomy of B.S. Bloom (1956) will be used for this purpose, i.e., cognitive-affective-psychomotor. Within each domain, the goals will be expressed as observable actions which the handgun learners will demonstrate under defined conditions.

Figure 20. (Concluded)

easy, and may demand considerable levels of such difficult-to-instill qualities as intuition, creativity, and insight. System design may well be more science than art, but good system design is always the province of artful scientists.

The authors make no claim to artistry, nor to possession of the creative or insightful instincts of the training designer. The sample design specification given in Figure 20 undoubtedly is deficient in numerous respects. In one major respect, however, it is a shining example: it addresses system performance requirements and nothing but performance requirements. Experts in handgun training possibly could look at Figure 20 and uncover instances where the offered proof of the ability to identify training goals is weak, inconclusive, or even incompetent. We submit, however, that those design specifications do not overlook even one aspect of the constituents of that ability, i.e., the specifications at least offer some proof for everything that needs to be proven. Neither do the specifications deal with anything that is not germain to the ability to identify training goals. Our design specifications are firmly rooted in the performance requirements that the Army Handgun Training System really faces. The APM provided the capability of identifying those requirements. As such, it is a valuable tool for any training designer.

The sketch at the right outlines the context in which the specification of design plans for the Army Handgun Training System takes place. The total process begins with the generic performance requirements of the Design Subsystem of any training system, i.e., the taxonomy given in Figure 7 above. The next step is the translation of those general performance taxa into terms keyed to the peculiarities of the training application of interest; in this case, Army Handgun Training. Next comes the development of concrete plans for insuring that the Army Handgun Training Design Subsystem will possess its specifically required potentialities, carry out its particular processes, and deliver the unique products required of it. Sample segments of such concrete plans appear in this section of the report and in Appendix B. Once the plans are approved, they must be implemented. In the context of our particular example, that means that steps must be taken to assemble the people, equipment, and procedures needed to develop effective handgun training for Army handgun users; to conduct activities appropriate to that development; and finally, to deliver usable handgun training products. At the final stage of development, those products are collected into an effective Program of Army Handgun Instruction that will enable soldiers to use their handguns to do the jobs for which the weapons are intended.



E. The Computer-Aided Model

1. General

The interactive computer system is being developed to aid users of the APM understand and apply the structure of the training system design model and to relate training goals and activities to appropriate learner progress measures. The system is being illustrated through a set of PASCAL-based programs operating on complex data bases using an Apple-II desktop computer.

It was recognized early that the STM and its emcompassing APM are somewhat toilsome to use. It was foreseen that a streamlining of the process, a reduction in the magnitude of effort required, and greater ease in applying the model can be achieved if an interactive computer system is employed. This research task was intended to determine the feasibility and resource implications of incorporating parts of the APM (specifically, the STM) onto an interactive computer system for machine-aided applications. The task included the examination and step-by-step documentation of procedures followed in one or more manual applications of the model. It then assessed how each step can be programmed on an interactive computer, especially those steps in the model application which necessitate the analyst's review of taxonomies. A sample application of the model on a small interactive system was also begun in this task.

2. Points of Departure for This Task

Since the APM is intended for use with any human-machine system, and all system development or evaluation efforts have finite and limited resources of time, money, and personnel, it is necessary to find ways of simplifying and hastening the analytic processes without undermining confidence in the results. If found to be too time-consuming or costly, any model risks being abandoned by potential users, regardless of how effective it can be.

Consider the magnitude of the process (or algorithm) for creating a general set of taxonomies and guidelines for applying the STM to any particular human-machine system. There is no doubt that the total number of populations that exist among the universe of human-machine systems is enormous. However, if one's principal interest is centered on a particular sub-universe of systems (e.g., training systems for military weapons), it may be possible to identify a finite, manageable set of populations whose members span the range of variables pertinent to performance/effectiveness specification of measurement of (at least) most of the systems belonging to that sub-universe. In particular, it may be possible to organize that finite, manageable set into subsets corresponding to the cells formed by interaction of the first two dimensions of the STM (see Figure 2).* This would produce

*At present, the model's third dimension (the System Hierarchical Structure) will be implicitly represented, based on the extent to which other systems which interact with the system of interest are covered by the automated model's data base.

fifteen sets of system taxonomies, with each set corresponding to the interaction of one of the three Descriptive Levels with one of the five Contextual Aspects. The existence of these sets presumably would greatly facilitate the application of the STM to any particular human-machine system belonging to the sub-universe of interest. To identify the total set of taxonomies for that system, one would search through each of the fifteen sets in turn, "pulling out" the populations to which the system belongs. Occasionally, one possibly would discover that the system also belongs to a population not contained in the available sets. That population could be added, so that the fifteen basic sets would "grow adaptively", incorporating more of the taxonomies associated with more of the systems of their sub-universe.

The compilation and use of taxonomy sets should be greatly facilitated by automated data processing. In one of the trial applications to just one subsystem of the BIFV, the STM produced several hundred taxa. The "finite, manageable set" of taxonomies for the class of all weapons systems easily could have several thousand or even tens of thousands of entries. Manual searching and extracting from such voluminous sets would be very laborious and error-prone. But if the sets were maintained in an interactive computer system, it might be possible to reduce the labor involved significantly. Ultimately, supporting software could be written so that, given certain descriptive features of the system of interest as input, the automated routine might take a "first cut" at selecting at least the Objectives Level Taxa (corresponding to the "what" of system performance). Of course, the human analyst could always amend those initial choices by deleting or adding taxa, but at least his or her search time should be shortened substantially. Furthermore, the computer-based implementation eventually could include a permanent memory of all of its past taxonomization applications. This could allow keeping track, for example, of the frequency with which each population in each lexicon has been selected and of the groupings of populations that have occurred in past applications. The sequence in which populations are presented to the human analyst for his or her consideration could be continually refined based upon the observed frequencies and groupings of previous selections. Given enough previous applications, the software could become progressively "smarter," and become capable of making steadily more accurate initial selections of taxonomies based on what it has "learned" in the past. Although it may never be possible to dispense entirely with the human analyst in the final selection of taxonomies, it should be possible to eliminate much of the work that presently is required. It should also be relatively easy to design the memory to permit new entries to be made, and even to delete old, never-chosen entries as time goes on.

The PASCAL programming language was selected for this sample application because a form of PASCAL is expected to be available in about 1984 for use at remote terminals throughout the Department of Defense. Various versions of PASCAL are now available for use on such computers as the Apple II and the DEC-20, both of which were potentially available for this task. Except for the newly announced IBM Personal Computer, no PASCAL compilers have been developed for other IBM computers to date, as far as can be

determined. Recently published manuals on Standard PASCAL, UCSD* PASCAL, Apple PASCAL and PASCAL-20 have been obtained for reference in this task. Although a desktop computer like the Apple II would not have the capacity to handle the model's ultimate information content, it was chosen as useful and convenient in this early demonstration stage to execute a sample program which can later be expanded and transferred to a larger capacity machine.

3. Selection of the Sample Application to be Programmed

The BIFV system has been analyzed (manually) more than any other with this STM/APM model, and it also is one in which major practical interest lies. Specifically, the most advanced application of the model to date is with the BIFV Training System, an important entity for which a general set and a particular subset of taxonomies have been identified under the first several model components. Because of this experience in applying the model and the project team's existing knowledge of the BIFVTS, the basic algorithm, guidelines and data sets are fairly well understood and were adaptable to a sample computer application with less effort than if one were to select a system not previously examined.

In order to keep the scope of this task within project resource limits, and since this was to be a sample application only, just one subsystem (Design) of the BIFVTS was considered for the main computer implementation (see Figure 5 earlier in this report). Furthermore, this implementation was carried down through only one set of task requirements associated with Curriculum Development, namely, Specification of Learner Testing. Other sets of tasks within Curriculum Development are:

- Specification of Training Objectives
- Specification of Training Content
- Specification of Training Methods
- Specification of Texts, Lesson Plans and Reference Sources
- Specification of Instructor Requirements
- Specification of Facilities Requirements
- Specification of Instructional Schedules
- Secification of Training Standards
- Etc.

By means of the narrowly defined example, this task attempted to illustrate the feasibility and value of guided general conceptualizations for helping to evaluate any system, the use of pre-established taxonomies at general and specific levels, the improvement of data bases in adaptive computer-aided processes, and the ability of the process to yield specific implications for system definition or evaluation measurement (if not some recommended specifications or effectiveness measures themselves).

*UCSD: University of California at San Diego.

4. Implementation Concepts

The key notion of branching down through sets, to subsets, and to sub-subsets is evident from the first steps in preparing for STM application. Figure 21 illustrates how the focus of evaluation and measurement narrows from all human-machine systems, to all training systems, to the BIFV Training System, to the BIFVTS curriculum development subsystem, and finally to the specification of learner testing within that subsystem.

The STM/APM components have a similar nesting structure, such as illustrated in Figure 7. In that Figure, taxonomies for a general design for Curriculum Development subsystem are listed for the first three contextual aspects (Performance Potentialities, Performance Processes, and Performance Products) at all three levels of system description (Objectives, Functional Purposes, and Characteristics). It is seen, by referring to the numbering scheme, that the sets of taxonomies at the higher levels branch down to nested subsets at the lower levels. The taxonomies for the "Specification of Learner Testing" are a subset of those in Figure 7. In operation with a computer, the analyst could be shown a display of the general Design taxonomies, and could identify for the computer those which apply to the area of specific interest (i.e., Specification of Learner Testing in the particular training system being considered). The computer could then guide the analyst through subsequent "menus" and selections until all the STM components have been applied at all system levels, and implications for evaluation measurement or system specification can be derived. Similar programming of the remaining components of the overall APM (beyond the STM portion) could lead to identification of actual measures or performance requirements, and eventually, perhaps, to recommendations for applying those identified measures or requirements.

5. Computer Programming Implications

Ultimately, a computer-aided realization of the entire analytic process is a major design, programming, and clerical task. The sample illustration of the computer-aided analytic system, developed using PASCAL on a small computer, contains only a small fraction of the information intended for the full system. More critically, although the demonstration appears to have the capabilities of the full system, many of the capabilities are simulated rather than developed as in the full system. (For example, searches may be done by simple linear procedures that would be too inefficient for use in the full system.)

In the development of the illustration, however, design concepts for the full system were considered. Only after the major design decisions for the full system have been made can a realistic subset be extracted for use as an illustration. In this development, the user-computer interactions and the user's abilities and experience are key concerns. As interactive computers have become more common in recent years, techniques have been developed to enable more efficient use of computer facilities by less expert users. Particular concern is being paid to relatively naive users--ones who seldom use

computers or who are unfamiliar with the current system. Techniques such as "menu selection," extensive "help" facilities, and interactive error correction procedures all make it easier for naive users to conduct work successfully on the computers without the need to reference written support documents or to call upon system experts for aid. The best of these procedures are sought and used as appropriate in the design of the user-machine interface for this task. For example, split-screen formats are considered to display "menu" data and user guidelines or instructions at the same time.

The data structure--the taxonomic information is being organized to reflect the complex interrelationships to be exploited by the users. The basic elements, or nodes in the structure, will be made up of key pieces of information for the user. But relating the nodes to each other is the key to having a powerful and useful data base. Multiple kinds of links were explored and are implemented as appropriate. For example, the overall data base has a tree structure like that partially shown in Figure 21, with successive nesting of subsets to more and more specific detail. But, to be useful in an interactive environment, the data base must have other ways of being scanned. For example, one must be able to access all "related" taxa of, say, performance processes. And "related," to be meaningful, may require each node or cluster of nodes to be judged on several content-descriptive dimensions.

To access the data structure, the user must be able to ask powerful questions, to use general queries to expand understanding, and to use intermediate answers to guide subsequent questions. This query system, dependent upon the data structure for its detail, must be a helpful and productive tool for the user.

Obviously, the more features present in the full computer system, the more flexible, powerful, and ultimately valuable to the user it can be. To program such features and to input a data base of the required complexity can be extremely costly, however, and a middle ground must be chosen such that the end product is both useful and cost-effective. At this point in the project, it is intended that the system initially be designed with as many features as possible. Designing is relatively inexpensive. With an overdesigned starting place, one can more knowledgeably develop the actual implementation. That is, one can compromise more effectively knowing the costs and benefits of specific capabilities than by starting with a reduced design in which the "extra" features have never been specified. Moreover, it may be that some desired features initially judged too cumbersome can eventually be put into the system, as costs of some operations are reduced or as more efficient procedures are devised. Such additions will be more easily implemented if the original design included them than if they were never contemplated in the initial work.

The outline in Figure 22 is an ordered list of items relevant to the design of a complete computer system. Included are features for the system, possible capabilities of the system, key questions about the user population

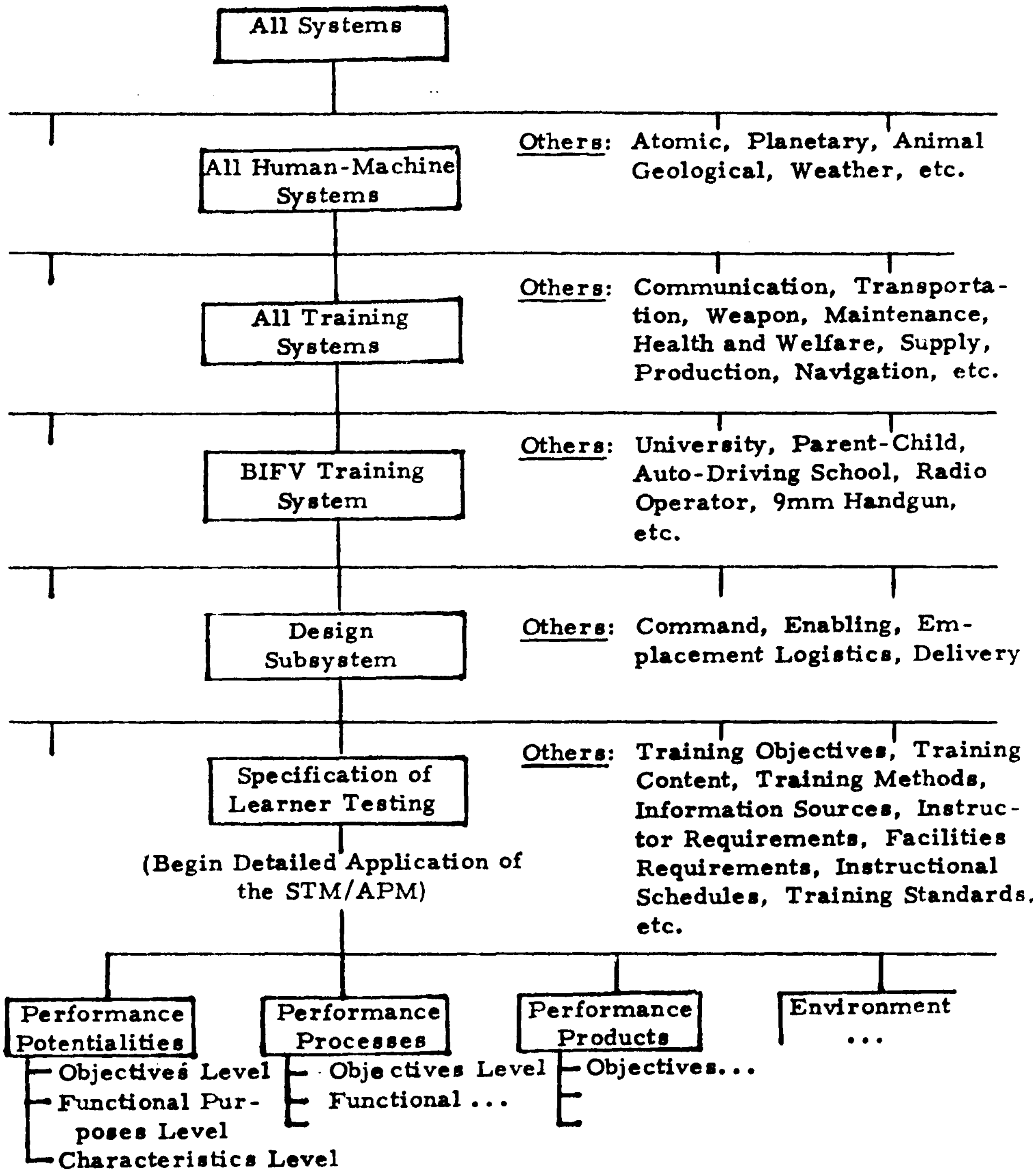


Figure 21. Branching Down Through Nested Sets as a Basic Concept in Applying the STM

I. Users: Range of kinds of users, subgroups described in terms of ...

   A. Rank or position
   B. Intelligence
   C. Content area experience/training
   D. Computer experience/training
   E. Purposes in using the system
   F. Experience with this system—amount, recency

II. Data base:

   A. Magnitude of the data base

      1. How much text
      2. How many nodes (e.g., taxa, performance aspects, measurement issues, MOEs/MOPs)
      3. How many node descriptors
      4. How much total storage required

   B. Structure, e.g.,

      1. Treelike hierarchy

         a. Up and down links
         b. Jump to parallel branches

      2. Overall structural dimensions, e.g., matrix dimensions:

         a. Descriptive levels
         b. Contextual aspects
         c. System Families (Hierarchical Structure)

      3. Node or substructure qualifiers

         a. Attributes, relevance and values or value ranges
         b. Ordered links (e.g., A causes B, B precedes C)
         c. Similarity links (e.g., A is like B, (A to B) is like (C to D))
         d. Co-occurrence links (e.g., A comes up whenever B is mentioned, or A never exists alongside B)
         e. Intensity of links, e.g., weak links passed over in general searches but followed in in-depth searches

      4. Node contents

         a. Same or different in different parts of structure
         b. Range of types of node contents, if more than one
         c. Necessary type/attribute identifiers

      5. Possibility of multiple classification (structure) schemes

III. Query language/user interface

   A. General design features, e.g.,

      1. Menus for users to search to make branching choices
      2. Interrupt with stack memory—whether users can interrupt to perform a new task, then resume the prior task
      3. "Help"—a general panic button to have the system provide extra information to help the user find out where he is and what he can do
      4. Restore/back up—the ability, in the middle of a complex search, to back up one or more decision points and resume in another search direction—without having to start anew
      5. Trace printout—the ability to order, at any point, a permanent copy of some or all of the previous search results
      6. Tutorial subprogram, to train naive users of the system on what the capabilities are and how to interact
      7. User comments—a facility by which users can comment on anything related to the system in messages to the system maintainers—with eventual feedback to specific users

   B. Nature of interactions

      1. Fixed-format user inputs vs. relatively free-format
      2. Command defaults to allow straightforward actions for naive users plus powerful abilities for sophisticated users
      3. Command prompting to help users compose commands
      4. English-like commands
      5. Forgiving of minor errors in constructing commands
      6. Quick system response time

   C. Search powers

      1. Keyed to structure of data base
      2. Sequential or parallel screening
      3. Allow logically complex selection rules

Figure 22. Items Relevant to the Design of the Computer-aided System

and the system uses, and other related issues. The list is an initial gathering of items considered in the design, rather than an outline of the system or a set of steps to follow in the design process.

Other aspects of the system, particularly record-keeping and dynamic modifications, represent a secondary level of design which need only be briefly discussed here. The system must keep track of who has used it and for how long, and there may be value to recording some session details as well. The system will permit modification, of course, but an important consideration is the source of such changes. The system designers can enlarge or modify the data base and change the interactive capabilities of the query system at will. The direction for such changes may come from outside, i.e., from content or system experts who have determined that a system expansion is in order. Changes may be originated by user comments--ones which report errors, awkwardness, or weaknesses in system performance. Finally, changes may occur because of the nature of activities on the system. If users always make one choice at a decision point, for example, the overt decision may be eliminated. If some choices or associations are always rejected, the data may be restructured to eliminate the possibility of those links. In these last examples, because the information needed for system change is resident in the system activity, it is theoretically possible to program the system to monitor such activity and modify itself.

6. Specific Demonstration of Interactive Computer Capabilities

Design goals for the ultimate computer system include power and user-friendliness. While the material to be make available to users through the computer system could be aggregated into printed volumes, the interactive approach has several potential advantages. Paramount is the opportunity for the user to only investigate the sections of the full STM relevant to a specific task and to be able to study--under the guidance of the system--all the relevant components. For a computer system which is well designed and implemented, users will come back to it frequently and benefit from the information available. The simplified program to demonstrate the kinds of capabilities attainable with a computer-aided version of the STM actually possesses far less than the full range of capabilities ultimately envisioned. However, the program and data bases are designed to clarify the full range of capabilities, through a combination of simulation and inference. The STM demonstration program is a partially working model: virtually all of the options, functions, data bases, etc., that ultimately will be available to a user of a full-fledged automated STM appear to be present in the demonstration version, but many of these would not actually "work" if the user were to attempt to select, implement, or access them.

Using this approach, the computer system presently includes four components briefly noted below:

- General Design Subsystem database - a tree-like hierarchy of curriculum development concepts--goals, processes, and products--capable of being divided into subsets based on content as well as hierarchy factors. Each "node" in the tree includes limb information to related nodes in the tree, descriptive information, and links to measures useful in determining whether, in an actual training situation, the node's goals have been met.

- Measures database - a structure of kinds and examples of measures for training situations to scale how well certain training activities have met their goals. The measures are ordered in a simple structure of more general and more specific examples and, in this instance, are linked to specific points in the content database.

- Programs to allow system maintainers to conveniently add to or modify the data bases.

- Programs for system users to selectively study the portions of the databases relevant to their own activities.

The system is intended for sophisticated and for naive users. Typically, user activity choices are displayed on the screen whenever user inputs are required. Abbreviations are permissible, so that users can type as much or as little as they need for their own confidence. A wide range of help is available at nearly every point in a session, and repeated errors lead to attempts by the system to help the user out of his dilemma. Much of the user's activity involves tracing paths through the databases to identify helpful content nodes and associated measures. For any session, the system retains the search route so that users can retrace their steps as desired. The system also allows information to be printed at nearly any point so that permanent records are available after the sessions.

Figure 23 compares the ultimate capabilities desired of a full-scale automated STM with the representations of those capabilities in the demonstration program. Appendix C presents details on the program, in the form of a flow chart with explanatory narrative. The demonstration based on the concepts of Figure 23 and Appendix C are considered to convey adequately the ultimate power of an automated STM, without having required a severe drain on project resources.

Currently, the initial formulation of the programs and initial exemplary databases are being completed on the Apple II. More detailed design goals and descriptions of the computer system are presented in Appendix C.

THE FULL-SCALE, ULTIMATE VERSION OF THE AUTOMATED STM SHOULD:	THE DEMONSTRATION VERSION OF THE AUTOMATED STM DOES:
Contain complete taxonomies for a wide variety of system types. Each taxonomy, for each type of system, should encompass all of the system's subsystems, and should cover potentialities, processes, products, environments, and constraints on the objectives, functional purposes, and characteristics levels of system description.	Contain taxonomies only for two subsystems of a generalized training system. Those two subsystems will be curriculum development and instructor preparation. Further, no taxa of environment or general constraints will be included. The demonstration program will convey the impression that other types of systems are available in the data base, but in reality none will be selectable.
Provide two different, but related, classes of application, viz., 1) the selection of measures of performance and effectiveness, and 2) the development of system design specifications.	Imply that both applications are available, but in reality software will be prepared only to support measures selection.
Provide measures-relevant taxa for a wide variety of aspects of performance for any selected system. In particular, if the user has indicated interest in "training systems," the user should be able to specify any of a large number of aspects of training system performance for which particular subsets of taxa have been identified in the data base.	Provide measures-relevant taxa for no more than two aspects of curriculum development performance (probably "testing specification" and "learning objectives specification") and for only one aspect of instructor preparation performance (probably "conduct of testing"). Other aspects of performance will appear to have been identified in the data base, but their taxa subsets will not really have been defined. Note, however, software will be prepared that will permit a user to define a taxa subset, on-line, for a newly specified aspect of performance.
Provide a comprehensive listing of the issues and implications for measurement, relevant to a specified aspect of performance, that derive from each member of the taxa subset associated with that aspect of performance.	Provide selected, exemplary measurement issues—strictly relevant to "testing specification" performance—and only for the objectives level and functional purposes level taxa associated with a curriculum development subsystem's performance of "testing specification." Note, however, software will be prepared that will permit a user to define measurement issue information, on-line, for any specified taxon.
Provide suitable measure or measures to address every issue and implication raised by every taxon associated with a specified aspect of performance.	Provide measures for the issues raised by only a select sample of the taxa associated with "testing specification." Note, however, the ability of the user to define measures, on-line, will be demonstrated.

Figure 23. Comparison between Demonstrated and Ultimate Capabilities of a Computer-aided STM

IV. APM APPLICATION PROCEDURES

The two general applications of the Analysis Process Model are to the design of human-machine systems and to the measurement of the performance and effectiveness of those systems. The foregoing discussions and examples of those applications in the training system context should have made one fundamental point abundantly clear: system design and system measurement deal with exactly the same issues. Those issues are the constituent requirements of system performance. The designer and the evaluator are (or should be) interested strictly in the capabilities (potential performance) their system is supposed to have; the activities (process performance) it is supposed to carry out; and, the goods and services (product performance) it is supposed to deliver. The designer's job is to see to it that the system does in fact meet all of its requirements for potential, process, and product performance. The evaluator's job is to check on how well the designer's job is done.

Sometimes a system designer may achieve somewhat more than was required: the system might not only deliver all required products, for example, but also some additional useful goods or services that weren't among those essential to meet the needs of the system's sponsor. Designers expect those kind of achievements to be applauded and rewarded. Evaluators, however, have to take a long, skeptical look at such design "extras." The evaluator has to ask, how much is this additional item going to cost the sponsor? Could any economies in time, equipment, funds, or other resources be realized if we dispensed with this "extra"? Most importantly, does the delivery of this "extra" in any way impair the system's ability to have available its essential capabilities, carry out its essential activities, or deliver its essential goods and services? Depending on how these kinds of questions are answered, the designer's expected applause might materialize as boos. The evaluator might report that, far from deserving additional credit, the "extra" good or service might really be a system defect, that absolutely must be removed. The evaluator is the designer's *advocatus diaboli*: the one who has to insist on rigorous proof that the designer's work has met all applicable requirements. "Extras" are nice, but only after all of the essentials are met.*

Sometimes, too, the performance-oriented shoe is on the other foot. It is far too common that evaluators find fault with a system designer's work that really satisfies the performance requirements very well. Such invalid objections arise from the evaluators' preconceived ideas about *how* the system should achieve its requirements, instead of from the basic question of *whether* the system performs as it should. A case from the early days of World War II is illustrative:

*Design "extras" that truly do not impair achievement of real performance requirements in any way probably are as rare as the free lunch.

In order to maintain her essential supply of materials from abroad, Britain equipped much of her merchant fleet with anti-aircraft guns. Those guns were in short supply, and were much in demand by the military for installation in shore batteries and on men-of-war. The Royal Navy conducted an "evaluation" of the effectiveness of the merchantmen's guns which showed a very small number of German aircraft had been brought down by the merchant fleet. The ratio of a-a gun shots to aircraft "kills" was vanishingly small. On the strength of that study, the Navy argued for the removal of guns from the merchant fleet, so that the weapons could be employed more "effectively" by the "professionals." That argument nearly carried the day, until someone pointed out that the guns weren't there to kill German aircraft, but rather to keep British ships afloat. In fact, the a-a guns were highly effective, in that a much smaller percentage of armed merchantmen were sunk. The sailors used their firepower to keep the aircraft at bay, and that was all that they had to do to achieve their performance requirement.*

The designer, then, must stand ready to defend the system and its specifications strictly on the issue of its performance. The designer has the right, and the obligation, to insist that any criticism of his or her work be shown to stem from a real performance deficiency. Otherwise, good work may be needlessly corrupted.

System design and system measurement thus really are two different aspects or views of precisely the same thing. They are more closely related than are two sides of the same coin, for they interact constantly. At the outset of a system development project, a designer takes a set of performance requirements, identifies the attributes of people, procedures, and equipment needed to meet those requirements, and develops a preliminary plan for securing those attributes in the system to be built. The designer's work at this conceptual stage is oriented heavily toward the performance potentialities. The plan of course addresses how the processes will be carried out, and what the products will look like. But the plan's basic purpose is to demonstrate that the system will have what it needs (in terms of abilities) to carry out the processes and deliver the products.

*Given that one of our sample applications of the APM is to Army handgun training, it is relevant to note that a soldier's handg... .s very closely analogous to the merchant ship's a-a gun. In each case, the basic purpose is to defend the user, not necessarily to kill the enemy. Handgun training thus logically should emphasize defensive operations. Unfortunately, the training often boils down to target practice.

Meanwhile, the evaluator examines those same performance requirements and their associated system attributes, and forms a set of measures to be used to determine whether the system has those attributes and meets those requirements. The evaluator applies those measures to the designer's plan. The evaluator's interest, too, is at this time principally on the requirements and attributes of potentiality. Will the system have what it takes to carry out the processes and deliver the products actually required? Is the plan sound and workable? This is the proposal stage of design and evaluation. The designer says "here is how I intend to go about building the system to meet its performance requirements." The evaluator responds "here are the specific performance defects that I have found in your plan." The designer should have a chance to rebut, to challenge whether the evaluator's conclusions truly are based on the performance requirements. Once the evaluative conclusions are validated, the designer modifies the plan to remove the performance defects, and begins to build the "real" system. This means that attention shifts from potential ("on paper") performance to actual process performance. As the designer implements the processes the evaluator again applies the measures to determine whether the requirements are being met. At this stage, the evaluator might well uncover some defects in potentiality that escaped notice during the proposal evaluation. To the extent that some early products begin to emerge, the evaluator might also find some product defects. But the focus here is on process performance. Is the system conducting the activities that should be conducted? Is the plan being followed? Are the processes being adapted to meet the needs emerging in the real world of system development? The evaluator continually monitors the designer's work at this stage, from time to time reporting "what you are doing there isn't quite what is needed." Again, the designer may challenge the evaluator's observations, to insure that they address real performance defects. Upon conceding that the defects are real, the designer modifies the processes (and takes steps to acquire any missing potentialities needed to implement the processes properly) to correct those defects. Work continues, progress is made, always under the watchful eyes of the evaluator. At some point, the system begins to deliver its products. Once again, the evaluator applies the measures. Here, too, it is possible that previously unnoticed defects in potential or process performance may surface. The accent, however, is now on how well the delivered goods and services meet their requirements for acceptance. The designer says "here are the goods you wanted." The evaluator might reply "these goods aren't good enough," and state exactly how they are deficient. Provided that the evaluator's dissatisfaction is based on valid product performance requirements, it will be incumbent upon the designer to "make good" the goods. The designer might be able to do that simply by repeating the production process somewhat more carefully. However, it might also be necessary to re-design the processes, or even to re-design the system's potentialities, in order to produce the proper products.

What we have sketched on the previous few pages of course is a general outline of an interactive design/measurement process for human-machine systems: in other words, a general procedure for applying the APM. It should be evident that design and measurement are indispensible activities within this Analysis Process. Further, they are <u>living</u> activities, born with

the system concept, growing with it throughout its construction, and remaining with it throughout the system's active life. Every design step demands a corresponding measurement activity. Every measurement finding demands a design response.*

Figure 24 depicts the general procedures for APM application in the Training Systems context. As shown, the responsibility for designing and measuring a training system is shared by the suprasystem sponsoring the development and operation of the training system; by the Command Subsystem; and by each of the other training subsystems. Training system design activities take place at two levels: at each of the operating subsystems, and at the total training system level; Command performs the design function commonly known as "system integration" in support of total system design. Training system evaluation activities take place at all three levels: each subsystem informally measures its own performance in designing its approach to its performance requirements, and in meeting those requirements; Command formally evaluates each of the individual subsystem's performance, and informally evaluates total training system effectiveness; the sponsoring suprasystem formally evaluates the effectiveness of the total training system. In carrying out these activities, all three levels participate in applying the APM.

Details on the APM application procedures are given below, in reference to each functional block in Figure 24.

Block 1: Sponsor identifies the basic needs for which training is to be developed and delivered.

Following the definition used in Interservice Procedures for Instructional Systems Development (Branson et al., 1975), a training need is "a measurable discrepancy between the actual world as it exists now and the world as it ought to be." Such discrepancy of course is perceived as a dearth of people qualified to perform some job that the sponsor wants performed. This could arise because the job is something brand new: for example, BIFVs are going to be deployed and there is no one who has ever manned a BIFV. Alternatively, it could arise because the sponsor is unsatisfied with the way in which an existing job is being performed: for example, combat studies may show that soldiers are woefully unsuccessful in defending themselves with their handguns. A discrepancy could also stem from a combination of these circumstances: for example, the Army may be about to introduce a new handgun to replace its current .45 and.38 calibre models, and may be dissatisfied with the way in which soldiers were trained to use the older weapons. This could lead to a decision like the following: "As long as we're going

*In many cases, the appropriate design response to a given measurement finding is "don't change anything!"

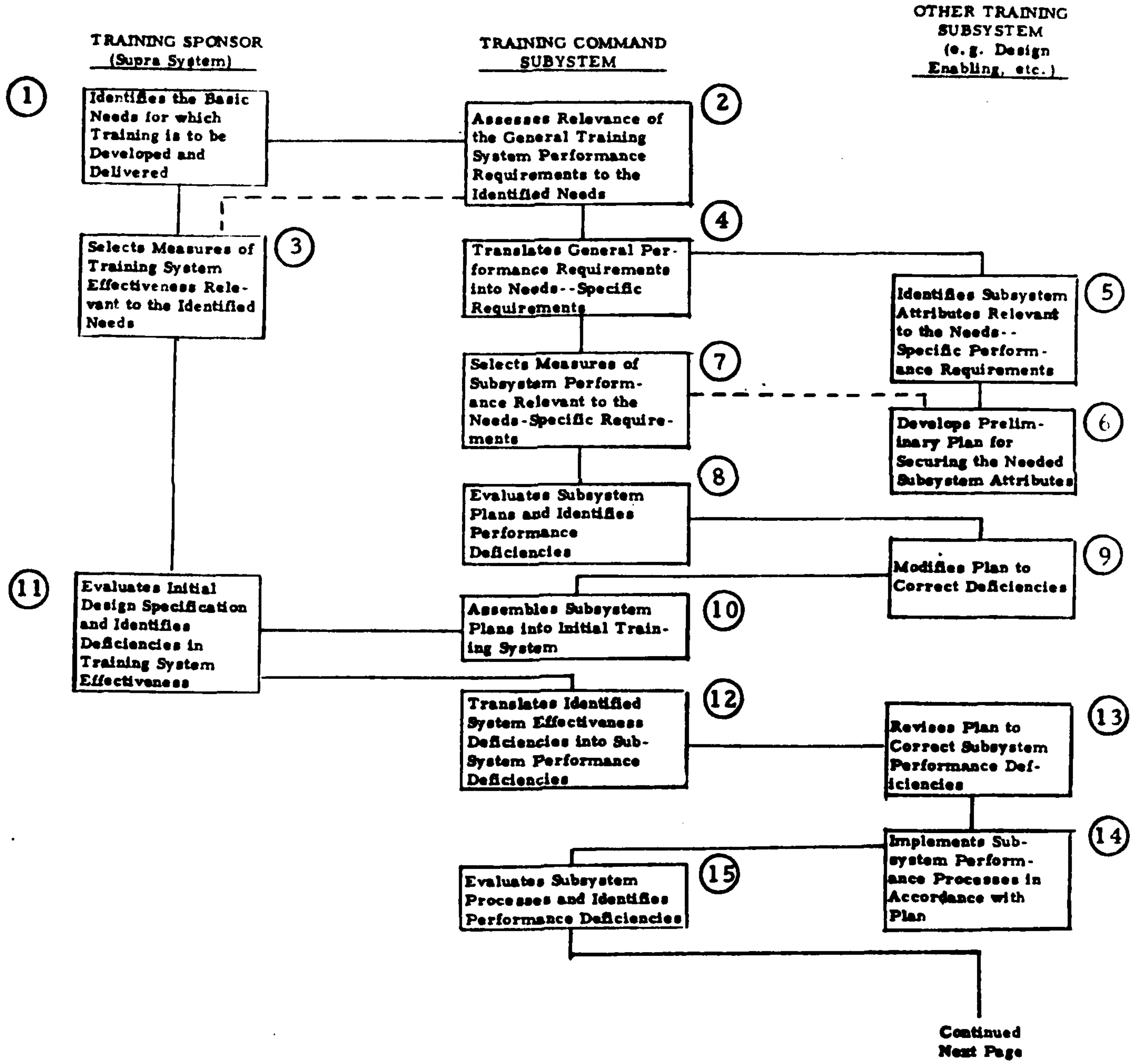


Figure 24. General Procedures for Applying the APM to Design and Measure Training Systems

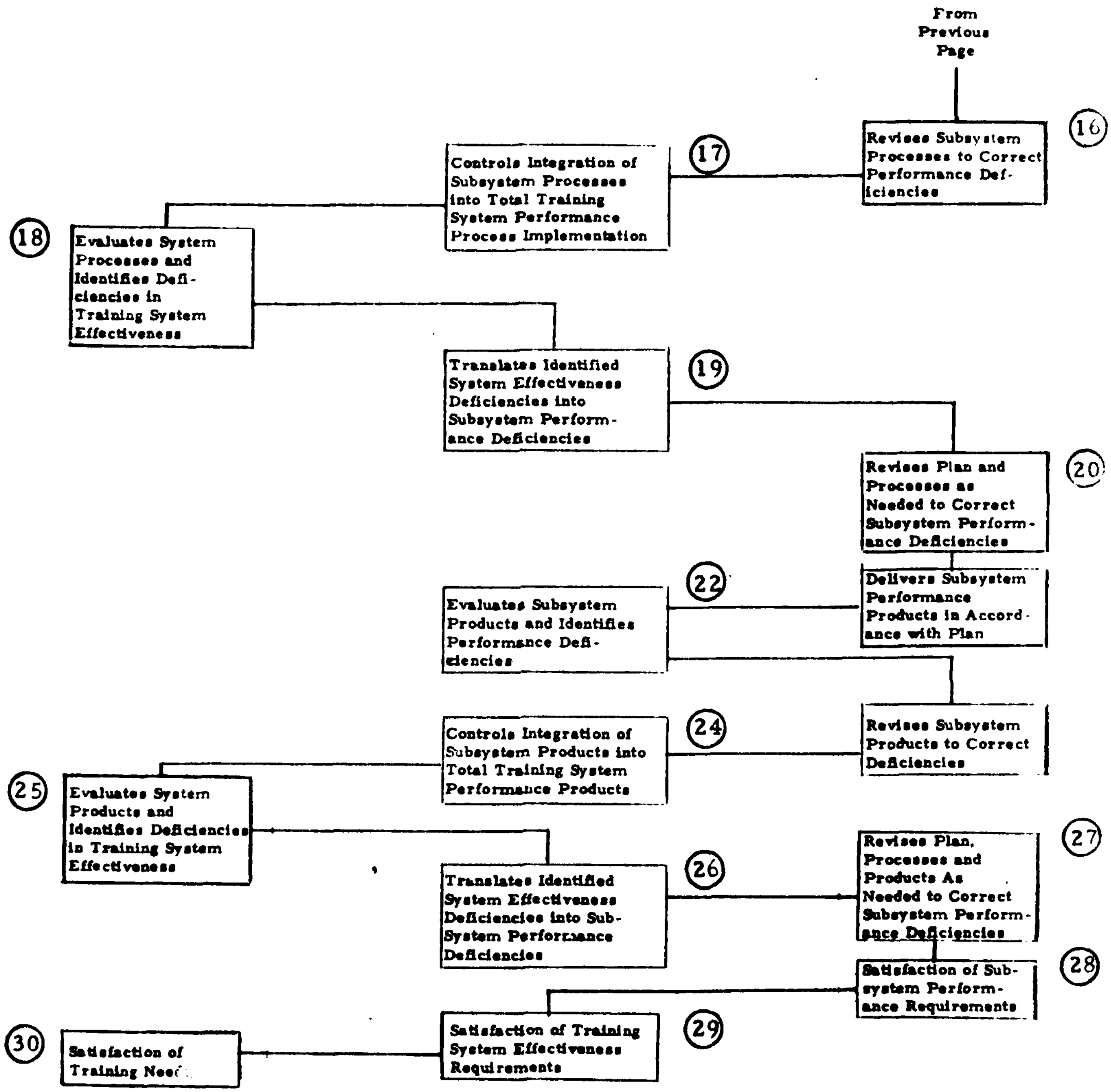


Figure 24. General Procedures for Applying the APM to Design and Measure Training Systems (Cont'd)

to have to develop new handgun training anyway, let's do it right this time and try to teach solders to use the weapon as it actually needs to be used in combat."

It is up to the sponsor to define the training needs, and thus to establish the scope of APM application. These needs usually aren't, and need not be, expressed in behavioral terms: extraction of required behaviors from the identified needs is a subsequent responsibility of the Training Design subsystem. But the expressed needs must totally encompass the job that the sponsor wants performed, so that the training system designers can do their work in the appropriate ballpark. Along with the needs, it is also up to the sponsor to provide or point the way to all available information concerning the job to be trained.

Block 2: Command assesses the relevance of the general training system performance requirements to the identified training needs.

The general performance requirements for the Training Design subsystem were given in Figure 7, while Figure 8 presented the general requirements for the Training Enabling Subsystem. Similar general performance requirements exist for the Emplacement, Logistics, and Delivery Subsystems as well as for the Command Subsystem itself. Depending upon the particular training needs to be satisfied, it might be that some of those general performance taxa do not apply to the Training System in question. The sponsor might, for example, have already performed a job analysis with which the sponsor is satisfied (in effect usurping a portion of the performance requirements and responsibilities of the Design Subsystem). As another example, if the job to be trained is truly brand new and radically different from all previous jobs, the Design Subsystem wouldn't need to analyze existing instruction for that job (none would exist). Thus, one of the initial responsibilities of the Command Subsystem would be to determine exactly which of the general training system performance requirements do apply to the application at hand.

Block 3: Sponsor selects measures of training system effectiveness relevant to the identified needs.

The sponsoring suprasystem is interested in "bottom line" results: it needs to determine, ultimately, whether its identified training needs are met. From the sponsor's point of view, the training system will be effective if and only if it produces the qualified people needed to do the job that the sponsor wants done. The measures of training system effectiveness thus are job performance measures. The sponsor needs to know: will the learners who emerge from the training system be able to perform the job the way we want it to be performed? For example, will the soldiers who receive handgun training actually be able to defend themselves

successfully in close-quarters combat with enemy soldiers? Will the soldiers who are trained to be BIFV gunners actually be able to operate the weapons to engage and destroy enemy targets? If these kinds of questions are not answered affirmatively, the sponsor will conclude that the training system is ineffective, because it fails to satisfy the sponsor's training needs. It will not impress the sponsor if the training administrator were to argue that "Okay, so our learners can't really perform your job; but you have to admit that we built some really superb classrooms and prepared some very attractively packaged lesson plans, and our cafeteria turned out some very tasty meals. Doesn't that count for something?" In fact, it counts for just about nothing: about as much as it counts to a bereaved widow to be informed that her late husband's operation was "technically, a success."

The sponsor will derive direct measures of training system effectiveness by applying the APM to the operating system for which training is to be developed. For example, the APM would be applied to the BIFV Carrier Team Subsystem to determine its performance requirements, from which in turn gunner performance requirements and measures of gunner performance would be derived. However, the sponsor will also need indirect measures of training system effectiveness, i.e., measures that will disclose whether the planning and development of the training system is on the right track. Those indirect measures will be derived from the training system performance requirements submitted for review and approval by the Command Subsystem. That derivation is depicted in Figure 24 as the dashed line connecting blocks 2 and 3.

Block 4: Command translates the relevant generic training system performance requirements into expressions specific to the identified training needs.

In the trial application to the U.S. Army Handgun Training System, the authors learned that the general Design Subsystem performance taxa (as presented in Figure 7) did not lend themselves as readily to handgun training specifications as one would wish. The problem was not that the taxa weren't relevant to handgun training. Rather, the general expressions simply weren't tailored to the nuances of that particular training enterprise: they didn't explicitly impart a "handgun flavor" to the performance requirements. It was determined, therefore, that an intermediate step was needed to bridge the gap between generic performance requirements and a system-specific plan for meeting those requirements. The intermediate step was to translate the general requirements into expressions tailored to the particular system of interest (in our case, Army 9mm Handgun Training). Samples of the "tailored" taxa were given in Figure 19, above, and in Appendix B. One comparison is reproduced here:

Generic Design Subsystem taxon	Corresponding Handgun Training taxon
"The Subsystem must be able to define the total scope of learning." (Taxon 1.1.1)	"Given a list of Army handgun users and uses, the Design Subsystem must be able to define the scope of learning needed for each user/use in terms of the knowledge, skills, and attitudes required."

This translation produced much additional verbiage, but it was helpful verbiage: specific details to which design specifications could easily be written. Hence, this "tailoring" of generic taxa to specific training needs is felt to be an essential step in the APM Application Procedures.

Block 5: Subsystem identifies its attributes relevant to its needs-specific performance requirements.

Upon receiving (from Command) its own, tailored set of performance requirements, each training subsystem takes the first step toward planning for satisfying those requirements. Of course, the various subsystems do not do this simultaneously, but rather in a logical sequence: much of the Design Subsystem's inital work must be completed, for example, before the Enabling Subsystem's performance requirements can be properly tailored. However, at the proper time each subsystem applies the APM to take that first step, which consists of identifying the attributes or features of the people, equipment, and procedures it must bring to bear to do the job. This is a subsystem-level analysis of the performance requirements to identify how those requiements impact on the subsystem's basic components.

Block 6: Subsystem develops preliminary plans for securing the required attributes.

These preliminary plans are the first output of the training design process. In the plans, each subsystem states the attributes it needs to achieve its assigned performance requirements; documents proof of its possession of certain of those attributes; identifies those attributes that it does not now possess and documents what it feels will be workable means of acquiring those missing attributes; and states the resources and other support it must have to implement those means. The Subsystem is aware that Command will carefully review and evaluate the submitted plans. Ideally, therefore, the Subsystem attempts to "anticipate" the evaluative measures that Command will apply to the plans, and writes the plans in a way that will produce "high scores" on those measures. That is, the Subsystem informally evaluates its own plans (and measures its own

potential performance) before submitting the plans to Command. This "first tier" of evaluation gives a valuable boost toward an effective design specification provided that both the Subsystem and Command have applied the APM properly to develop valid measures of Subsystem performance.

Block 7: Command selects relevant measures of Subsystem performance.

This is the formal application (by Command) of the APM to develop the valid measures of Subsystem performance discussed above. It is this set of measures that the operating Subsystem attempts to "anticipate." In practice, of course, it is completely reasonable that Command may inform the operating Subsystem of the measures that will be applied to the Subsystem's plans. Command, after all, desires that measurably good plans emerge from the Subsystem.

Block 8: Command evaluates Subsystem plans and identifies performance deficiencies.

This starts the first wave of formal evaluation in the APM application sequence. Command applies its measures to the plans, producing concrete, quantitative ratings of their "goodness." The emphasis naturally is on the degree to which the plans demonstrate achievement of the potentialities of performance, although such measures of process and product as can be applied at this planning stage will also be taken. Command reports its findings back to the operating subsystem, pointing out specific deficiencies that must be corrected. These evaluative findings demand a design specification response.

Block 9: Subsystem modifies its plan to correct the deficiencies.

This is the design specification response to the first wave of evaluation. Command has informed the Subsystem that specific deficiencies exist in the plan. Those deficiencies include particular Subsystem attributes that are essential for adequate performance, and which are missing or inadequately demonstrated in the plan. The deficiencies may also include some inessential or even detracting attributes of the Subsystem that have been built into the plans. The operating Subsystem modifies its plan to remove the attribute deficiencies, i.e., modifies the proof of its fitness for the particular training application.

Block 10: Command assembles the Subsystem plans into an initial design specification for the total training system.

At this stage, Command exercises its overall system management responsibility and integrates the various plans into one comprehensive proposal for system design. This is an important responsibility. The integrated plan must demonstrate not only that

each subsystem can do its proper work, but also that all their work will "fit together" well. A particularly significant aspect of the integrated plan is its ability to prove that Command can adequately discharge its management responsibility on a continuing basis.

Block 11: Sponsor evaluates the initial total system design specification and identifies deficiencies in training system effectiveness.

This is the higher level equivalent of Block 8. It completes the first wave of formal evaluation. The emphasis remains on performance potentialities. Here, however, the focus is on the integrated training system's potentialities. This reflects the Sponsor's abiding interest in "bottom line" training results. In this present case, the interest is on the potential for satisfying the Sponsor's training needs. The Sponsor doesn't much care whether a defective potentiality traces back to the Design Subsystem, or the Enabling Subsystem, or whatever. Sponsor has "hired" Command to perform that level of diagnosis. Sponsor simply documents total system deficiencies, and passes these back to Command with an order to correct them.

Block 12: Command translates identified system effectiveness deficiencies into subsystem performance deficiencies.

Command performs the detailed diagnosis for which it was "hired," and reports its findings back to the operating subsystems. This forces another (final) design specification response.

Block 13: Subsystem (again) revises its plan to correct its performance deficiencies.

This is the "final" design specification response to the first wave of evaluation. Of course, this response will be evaluated by Command and subsequently by the Sponsor (after plan integration). It is possible that those evaluations could lead to further revisions, further evaluations, more revisions, etc. Fairly soon, however, Sponsor would be expected to lose patience and start to look for another training team to satisfy its needs.

Block 14: Subsystem implements its performance processes in accordance with its plan.

Assuming that Command finally approves the Subsystem's plans, and Sponsor finally approves the integrated plan, the plans finally go into effect. The focus of Subsystem performance shifts from potentialities to processes.

Block 15: Command evaluates Subsystem processes and identifies performance deficiencies.

This starts the second wave of formal evaluation. Just as in Block 8, Command applies its previously selected measures (Block 7) to the Subsystem's performance. But now, the principal focus is on process performance. The Subsystem has moved from the "on paper" design specification stage to the active design implementation stage. Evaluation similarly moves away from the activities-as-planned to the activities-as-implemented. Any deficiencies noted in that implementation are reported back to the operating Subsystem.

Block 16: Subsystem revises its processes to correct the deficiencies.

This is the design implementation response to Command's second wave evaluative findings. Command has pointed out that the Subsystem's activities are deficient: it may be doing some things that it shouldn't, it may be failing to do some things that it should do, or both. The Subsystem responds by changing what it does. Note that some of these process deficiencies may arise because the Subsystem has deviated from its plans: it may be doing some things differently from the way it proposed to do them. But note, too, that some process deficiencies may arise precisely because the Subsystem adheres to the plan, refusing to change with changing conditions. The plan, any plan, rests on certain assumptions about how the work will unfold. No plan is foolproof. The wise system designer will not abandon the plan at the earliest opportunity, but neither will he or she insist blindly on sticking to it when it becomes clear that things aren't working out as they were expected to. Process evaluation is not simply a matter of checking up on deviations from planned performance, although that is one facet of concern. Rather, true process evaluation is the determination of whether the system is doing what it should, given the conditions of the real world. If the evaluator's process measures are based on the true process performance requirements, he or she will uncover the real process defects, and not simply disparities that may or may not be bad.

Block 17: Command controls the integration of the various Subsystem processes into a total training system process implementation.

This is another stage at which Command executes system management. Now, Command's responsibility is to see to it that the work-as-carried-out by the individual Subsystems merges smoothly as it should. Previously, the concern was with the fitting together of the work-as-planned.

Block 18: Sponsor evaluates total system process implementation and identifies deficiencies in training system effectiveness.

This completes the second wave of formal evaluation. Now, the Sponsor looks at what the total training system actually is doing, and asks whether that promises progress toward satisfaction of the training needs. Any system activities that are either a hindrance to realizing those needs or merely superfluous are pointed out to Command as process defects.

Block 19: Command translates identified system effectiveness deficiencies into Subsystem performance deficiencies.

This is identical, in word and spirit, to Block 12, although the deficiencies with which Command now deals are likely to be process- rather than potentiality-based.

Block 20: Subsystem revises its processes and its plans, as needed, to correct its performance deficiencies.

This is another design implementation response to a set of evaluative findings. Of course, changes in processes that are underway may necessitate changes in processes planned for subsequent implementation. Thus, design specification response might also be needed.

Block 21: Subsystem delivers its performance products in accordance with its plan.

After all parties have approved the revisions to the processes, the work picks up again. Eventually, products emerge. The focus has now shifted from design specification through design implementation to design fruition.

Block 22: Command evaluates Subsystem products and identifies performance deficiencies.

Now the third wave of formal evaluation begins. The Subsystem performance measures once more are applied, this time with special emphasis on product measures. Command now has something to say directly about the goodness of the Subsystem's goods.

Block 23: Subsystem revises its products to correct the deficiencies.

This is the design fruition response to the third wave of evaluation. To the extent that the Subsystem's goods are deficient, the Subsystem must "make good" the goods. Sometimes this merely requires placing a few "final touches" on the delivered goods: a bit of polishing here and there, a few more dabs of paint, correction of some typographical errors, deliverance of the service with a smile

rather than a frown, etc. Other times the "making good" requires scrapping the submitted product and completely replicating the process that produced it, this time with much greater care. When that sort of situation develops, the blame often can be partially placed in a defective process evaluation: if the original process was performed so poorly that the product had to be scrapped, the evaluator probably should have discovered that fact <u>before</u> the product emerged. At still other times, the only way to "make good" on the product is to scrap the processes of production and devise new, more effective products, that is, a fundamental redesign of the system may be needed. All evaluators know that this kind of situation does sometimes arise. But they also know that, when it does, there often are defective evaluations of potentiality and process buried somewhere in the system's history.

Regardless of whatever it takes, any defective goods need to be "made good."

Block 24: Command controls the integration of the various Subsystem products into a set of total training system products.

Now it is the work-as-delivered that must be made to "fit together." Conflicts and inconsistencies between the interacting products of two or more subsystems must be removed, so that an acceptable total package may be delivered to the Sponsor.

Block 25: Sponsor evaluates total system products and identifies deficiencies in training system effectiveness.

This completes the "final" wave of formal evaluation. Here, the Sponsor can come to grips with the bottom line of all bottom lines: Does this now-fully-assembled training system actually satisfy the Sponsor's training needs? To the extent that any needs remain unsatisfied, training product defects will have been found.

Block 26: Command translates identified system effectiveness deficiencies into Subsystem performance deficiencies.

Just as in Blocks 12 and 19, Command performs the detailed diagnosis to determine how the defective work can best be corrected. Now, of course, it is diagnosis of defective products that claims most of Command's attention.

Block 27: Subsystem revises its products, processes, and plans, as needed, to correct its performance deficiencies.

This is another design fruition response to a set of evaluative findings. Depending upon exactly what is needed to "make good" its goods, the Subsystem may also have to make a design implementation

response (revise its processes), or even a design specification response (revise its fundamental plans and capabilities).

Blocks 28, 29 and 30: Suprasystem, system of interest, and other training subsystems affirm satisfaction of training needs and requirements.

Provided that all concerned ultimately "sign off" on the revised products, there will be across-the-board satisfaction of everyone's "bottom line." Each Subsystem is pleased, because it has met all of its performance requirements. Command is pleased not only because it has met its personal performance requirements, but even more because the total training system has been effective. Sponsor is happy because the training needs have been met. Each has its own point of view, its own definitions and standards of "happiness." That is to say, each faces its own taxa of performance requirements. There is a direct parallel between this three-tiered training structure and a professional baseball club. After a game, the center fielder (for example) might say, "I'm happy: when they threw it, I hit it, and when they hit it, I caught it." The manager might say, "I'm happy: we won." The owner might say, "I'm happy: by winning, and by continuing to win, we've brought paying customers into the ballpark."

This discussion, and Figure 24 on which it is based, of course is very much oversimplified. Evaluation and design don't (or shouldn't) actually proceed in three distinct waves. Rather, they are continual or even continuous activities that always are blends of potentiality, process, and product issues. Also, there truly is nothing "final" about a system design or a system evaluation, until the system ultimately goes out of business. All functioning systems always admit the possibility of improvement, and so always admit the need for additional evaluation and additional design. System technology, after all, steadily improves. As it does, formerly state-of-art system designs approach obsolescence, a trend that can only be halted by modifying the system's design to incorporate the newer technology. Evaluation and design are forever interlinked and forever functioning within any operating system. Evaluation and design are the two threads that weave the fabric of a total Systems Analytic Process.

V. RECOMMENDATIONS FOR FURTHER DEVELOPMENT AND APPLICATIONS

As noted in Section II, the ultimate objective of this APM development work is to provide users with a uniform, thorough, adaptive and efficient procedure to aid in the process of deriving the most meaningful design specification requirements, design specifications, evaluation measurement requirements or evaluation measures for any planned or existing human-machine system (particularly a training system). In keeping with that objective, the APM development project so far has resulted in the following main products:

- An annotated bibliography of the manned systems measurement literature (244 documents cited and abstracted).
- An initial analytic process model for systems design and measurement.
- A generalizable taxonomy of measurable attributes for the surveillance function found in many manned systems.
- A generalizable model of training systems and their component subsystems.
- Generalizable taxonomies for the curriculum development (or design) and trainer training (enabling) subsystems of training systems.
- A sample application of the model for deriving effectiveness measures for Learner Testing Specifications within the emerging BIFVTS, including a generalizable taxonomy and application procedures.
- A sample application of the model for establishing Training System design requirements for the Army's new 9mm Handgun, including a generalizable taxonomy and application procedures.
- An untested procedural outline of a computer-based application of the APM for training systems measurement (using an Apple II computer).

This list represents considerable progress in an area that has been so difficult to standardize for so many years. The model development is just now beginning to yield the kinds of guidelines and sample applications that soon will allow it to be learned and applied by those who are its potential users. To help bring the APM development process to the point of application by the ultimate users, several tasks need to be carried out. These are listed in Figure 25. It is noted that the items are not necessarily independent of each other, but some tasks can be seen as being a part of others. They are listed

DEVELOPMENT

1. Further Develop the APM for Training Systems Measurement
2. Further Develop the APM for Training Systems Specification
3. Further Develop Training Systems Taxonomies for the APM
4. Further Develop Procedures for Measures Derivation
5. Further Develop Procedures for Identifying the Human Operators' Contribution to Specifications or Measures
6. Develop Procedures for Differentiating Specifications and Measures in Terms of Weighting Factors, Delay Tolerance and Criticality

APPLICATION

7. Apply the APM (Measurement) to an Existing Army Training System
8. Apply the APM (Design Specifications) to a New Army Training System
9. Improve Procedures for User Application of the APM (Measurement & Design)
10. Test Procedures for User Application of the APM (Measurement & Design)
11. Improve and Test Routinized Procedures Using Interactive Computer
12. Develop and Test a Training Program for APM Users
13. Train Users to Apply the APM (Measurement & Design)
14. Provide Mechanism for Future Modification/Improvement of the APM

Figure 25. Recommended Further Research on APM for Training Systems Specification and Measurement

separately, however, because they are identifiably distinct or limited in their purpose. For example, Item 1 can be seen as a general task, within which are several others including part of Item 3 and all of Item 4. Item 4, in turn, can be seen as having within it several others including parts of Items 5 and 6. Likewise, Item 2 can be seen as a general task, within which one could also place part of Items 3, 5 and 6.

Item 1. Further Develop the APM for Training Systems Measurement

The purpose of this research item is to continue developing the APM for measurement toward the ultimate goal of providing a practical and useful end product. The research task ultimately should address all stages of the model in order to extend its conceptualization and utility in each of its aspects. The research method should include model application with several existing or developing training systems to verify or modify its component parts, its adequacy, and its practicality. The effort should also produce improved and amplified procedures and guidelines for using the model.

Item 2. Further Develop the APM for Training Systems Specification

The purpose of this research item is analogous to that of Item 1, but as applied to the APM for specification. Sample applications should involve the specification of several new training systems. All component parts of the specification model should be addressed; concepts and definitions should be clarified and application guidelines should be developed. In addition, the utility of the model for assessing previously generated design requirements should be evaluated.

Item 3. Further Develop Training Systems Taxonomies for the APM

Currently, generalized taxa for any Design Subsystem have been developed and are being applied to BIFVTS issues for verification. A second generalized taxonomy for any Enabling Subsystem is also completed. Taxa for the additional generalized training subsystems should be developed and their applicability to BIFVTS issues should be verified through some real world comparison or evaluation, by subject-matter experts (SMEs) or otherwise. The same procedures should be applied as used in prior taxa development and verification of the taxa should be carried out. Taxa should be completed for each of the training subsystems of the BIFVTS.

Item 4. Further Develop Procedures for Measures Derivation

One of the most difficult-to-develop segments of the APM for measurement is that in which measurable attributes are determined and actual measures are selected (Ref.: Figure 1, blocks 6 and 7). Some progress has been made during the past year in beginning to identify specific procedures for measures derivation. More needs to be done, however, especially if computer-aiding is to be used for this segment. In particular, the analytic steps leading to measures derivation involve a determination of issues that imply a need to measure particular attributes.

Additional work is also needed to incorporate the MOE-MOP development steps into the APM, identify the relationships among MOE-MOP for systems-subsystems levels, and identify the relationships among the machine and human components in terms of contribution to MOE-MOP development or specification. This subtask can build on the current BIFVTS work, by continuing more sample or partial applications to increasingly complex issues of military training, both to verify and to improve the procedural guidelines. This is analogous to the earlier process of generating taxonomization guidelines in this research effort. The procedural guidelines allow for the derivation of MOE-MOP specific to given measurement purposes and provide for direct MOE-MOP (type) selection given the defined measurement purpose. Those guidelines, when better understood, will define the algorithm for measures derivation that then can be included in the computer-aided process.

Item 5. Further Develop Procedures for Identifying the Human Operators' Contribution to Specifications or Measures

One aspect of the measures derivation process (Ref.: Item 4) requiring particular attention is the determination of operator-centered measures. This task should identify the many (sometimes subtle) roles of human operators in the total system measurement and evaluation process. Researchers should apply the appropriate techniques of Human Factors Engineering to define the roles and influence of operators in the various system attributes selected for specification or measurement. Some researchers using the model in the future may require assistance in maintaining the necessary awareness of the human's role, so that their derived specifications and measures will give due consideration to operator-determined aspects of system performance.

Item 6. Develop Procedures for Differentiating Specifications and Measures in Terms of Weighting Factors, Delay Tolerance and Criticality

The practical aspects of model utilization suggest that there will be times when the full range of specifications or measures cannot be applied in its entirety, and that choices will have to be made to select only the most important ones for application. To aid the user in selecting those specifications or measures which are most important, a procedure should be developed which helps to rate or rank measures in accordance with such criteria as: criticality to mission performance, amenability to alternatives or corrective actions, tolerance to postponement or delay in application, or other criteria to be determined.

Item 7. Apply the APM for Measurement to an Existing Army System

This item involves extending the current developments of the Curriculum Development Subsystem of the BIFVTS to a practical application that also can serve as a validation or verification exercise. For example, the model can be applied in the context of the Training Effectiveness Analysis (TEA) of the BIFVTS planned by USAIS/USAIC. We understand that the TEA

is to begin in 4th Qtr FY 1982. Current developments can be extended to the point where derivation of specific measure sets for the effectiveness of the BIFVTS subsystem can be generated. These measure sets can then be examined for feasibility, validity and utility in the context of the TEA. It would be necessary to review the measurement issues to be addressed in the TEA that are relevant to the BIFVTS curriculum, and one or more of those issues should be selected as the basis for this task. The performance taxa pertaining to each selected issue and the measurement derivation guidelines should be used to generate a measures hierarchy for each selected issue. Differences between APM and TEA measures should be examined so that reasons can be determined for those differences. Commonalities should also be noted and their reasons understood. For practical reasons, this in-depth application and comparison should focus on a narrow aspect of the BIFVTS, such as Basic Gunnery Learner Testing. This task would also provide an opportunity to focus on human operator contributions to performance, such as motivation, attitudes, capabilities, and procedures under given environmental administrative and other constraints.

Item 8. Apply the APM for Design Specification to a New Army Training System

Initial extension of the APM to the specification of training system requirements was begun during the current contract year. This item is designed to extend and further explore this use of the APM as a tool through application to another new (or developing) training system. The purpose is to develop further and to verify, to the extent possible, the capability of the APM process to serve this function. This can be done through the "blind" development of training system specifications for a new or developing system to be selected by ARI. A comparative assessment can be carried out between design specifications or specification requirements as developed by using the APM, and similar specifications or requirements as developed by other methods, such as the Early Training Estimation System under development by the ARI Fort Bliss Field Unit. This task could also make use of the APM's capabilities both to generate new design specifications and to aid in the diagnostic assessment of previously generated design specifications. For the same practical reasons as mentioned under Item 7, this comparative application should take place in depth over a narrow aspect of the new training system.

Item 9. Improve the Procedures for User Application of the APM (Measurement and Design Versions)

This task would enlarge and improve the documented procedures and guidelines to be followed by users in applying the APM. It would also help to define the steps and algorithms essential to a computer-aided application of the model. The effort, in general, would make use of all the prior and concurrent applications of the APM, documenting the steps, the decision rules, the criteria and other factors that are essential to application procedures. One set of procedures would be expected for the development of performance taxonomies (Figure 1, blocks 1-3), but later blocks in the model would require

separate procedures for the Measurement version as compared to the Design version.

Item 10. Test the Procedure for User Application of the APM (Measurement and Design)

This task is preliminary to training actual users in the application of the APM. It would consist of providing a skilled, but APM-naive analyst (such as a "non-project" member of the Dunlap staff) with the procedures and guidelines, to be used in developing effectiveness measures in one application and design specifications in a second application. The purpose of this trial application effort is to refine and clarify the procedures prior to making them available to users through computer-aided facilities and training programs (Ref.: Items 11-13). If this task can be conducted with the interactive computer capability, then Item 11 becomes unnecessary as it would only duplicate this one. If the computer-aided capability is unavailable, then this task would be conducted manually with printed guidelines and instructions. The final product of this task should be an updated set of guidelines, procedures, sample applications, taxonomies, checklists, algorithms or any other available, documented aid to APM application.

Item 11. Improve and Test Routinized Procedures Using the Interactive Computer

This task is intended to build upon the existing computer-aided capability, by adding flexibility, instruction options, thoroughness, and data bases to the rudimentary computer-based model. It would also include a test of the procedures by a skilled, but APM-naive analyst (as in Item 10), to determine where modifications are required to clarify, simplify or otherwise improve their value and ease of use.

Item 12. Develop and Test a Training Program for APM Users

This task should include whatever remaining development effort is necessary to yield routinized (computer-aided) procedures for application by users. It should also include a test of those procedures by user personnel. Among others, likely candidate "users" for this test would be administrators and training developers of the USAIS. This task should consider the development of training/usage handbooks or guidelines for users; contractor development and conduct of user-directed workshops; and other techniques for user training in the APM process and its application. The task should also consider the training/usage of the APM process by various personnel types and for both possible purposes (evaluation of training systems and specification of training systems). The eventual procedures for training of users and for their usage of the APM should be as programmatic, proceduralized, routinized and simplified as possible. Advantage should be taken of the model's already demonstrated capabilities for flow charting, programming, indexing and other operations which make it readily reducible to routinized procedures. The user field test of these procedures should aim to

confirm their completeness and accuracy, their utility (based on the acceptance by users) and their validity (based on the quality and comprehensiveness of products).

Item 13. Train Users to Apply the APM (Measurement and Design

This task is one in which the previously developed and validated training program (Ref.: Item 12) is placed into operation to promulgate the APM as an analytic tool among potential users. It requires the sponsorship of a promulgating agency, which will be identified for this purpose by ARI. One possible agency to be considered for this dissemination function is the U.S. Army Training and Doctrine Command (TRADOC). Administrative preparations for this task item, in the form of preparatory explorations and information exchange with the possible promulgating agencies, should begin in the near future, even though the task itself is not likely to begin until a later date.

The task should identify specific users in specific agencies, and plans for administering the APM training program should be developed. A key office should be designated to administer and coordinate the subsequent training activities, and should be accessible for future inquiries from trainees and users. A cadre of trained instructors and an instructor training program should also be established as a continuing entity. One of the tasks of the APM program administrator should also be to serve as an information exchange and documentation center for users. The mechanisms and procedures for those administrative and technical capabilities should be designed as part of this task item.

Item 14. Provide Mechanisms for Future Modification or Improvement of the APM

To aid the promulgating office in carrying out its functions as an information exchange and documentation center for users, a technical capability should be established to include analysts, programmers and the interactive computer facility for APM applications. These resources would be used to maintain the APM, its associated data bases, and its various application routines and records. Users can then be helped with the latest fund of knowledge, techniques and experience. A current mailing list of users would allow for rapid distribution of application documents, program modifications, information requests, and suggestions to improve the value of this resource to users.

One of the most important sources of ideas to keep the APM as a useful and valuable resource is the user population itself. A method should be established for permitting and, in fact, encouraging users to supply feedback of application ideas to the promulgating office, with the assurance that those ideas will be given careful consideration and dissemination in the most appropriate manner. Dissemination can employ a newsletter, a "new application" description, a revised data base or even a message for CRT

display when users log on to use the model. In fact, one way in which users can conveniently communicate briefly with the APM central office could be via the interactive terminal, such as by typing in messages or inquiries after using the program or by pausing during use when a problem is encountered. The specific mechanisms for keeping the APM current and useful should be determined and implemented in this task item.

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VI. SELECTED BIBLIOGRAPHY

Bloom, R.F., Oates, J.F., Jr., and Hamilton, J.W. An Initial Analytic Process Model for Systems Measurement: Extensions of the Systems Taxonomy Model. (Final Summary Report). Darien, CT: Dunlap and Associates, Inc., 30 April 1981.

Branson, R.K., Rayner, G.T., Cox, J.L., Furman, J.P., King, F.J., and Hannum, W.H. Interservice Procedures for Instructional Systems Development. Tallahassee, FL: Florida State University, 1975.

Briggs, L.J. (Ed.) Instructional Design: Principles and Applications. Englewood Cliffs, NJ: Educational Technology Publications, Inc., 1977.

Dunlap and Associates, Inc. Instructor Training Institute for the Police Traffic Services Teacher: Participant's Notebook. Darien, CT: Dunlap and Associates, Inc., 1980.

Edwards, J.M., Bloom, R.F., Oates, J.F., Jr., Siptkowski, S., Brainin, P.A., Eckenrode, R.J. and Zeidler, P.C. An Annotated Bibliography of the Manned Systems Measurement Literature. Darien, CT: Dunlap and Associates, Inc., 30 November 1981.

Finch, G. (Ed.) Educational and Training Media: A Symposium. Washington, DC: National Academy of Sciences--National Research Council, Publication 789, 1960.

Finley, D.L., and Muckler, F.A. Human Factors Research and the Development of a Manned Systems Applications Science: The System Sampling Problem and a Solution. Northridge, CA: Manned Systems Sciences, Inc., July 1976.

Finley, D.L., Muckler, F.A., Gainer, C.A., and Obermayer, R.W. An Analysis and Evaluation Methodology for Command and Control: Final Technical Report. Northridge, CA: Manned Systems Sciences, Inc., November 1975.

Greer, G.D., Jr. Basic Training Effectiveness: A Discussion of Instruction Centralization, the Training Curriculum and Achievement Evaluation. Fort Ord, CA: U.S. Army Leadership, Human Research Unit, 1957.

Klotter J.C. Techniques for Police Instructors. Springfield, IL: Charles C Thomas, 1963.

Longo, A.A., Gaddis, J.T., and Whitehouse, B. Preliminary Evaluation Plan for U.S. Army Computerized Training System. Fort Monmouth, NJ: U.S. Army Signal Center and School, 1974.

McDonnell Douglas Astronautics Co.-East. A Survey and Analysis of Military Computer-Based Training Systems: (A Two Part Study). St. Louis, MO: McDonnell Douglas Astronautics Co.-East, 1977.

Smode, A.F., and Lam, K.D. (Eds.) Military Instructor Training in Transition. Orlando, FL: Training Analysis and Evaluation Group, 1975.

Thurmond, P. Development of Analysis, Design, and Development Techniques for Team ISD. San Diego, CA: Path Research, 1980.

U.S. Department of the Army. Interservice Procedures for Instructional Systems Development: Executive Summary and Model, Vol. I-V. Fort Benning, GA: U.S. Army Combat Arms Training Board, TRADOC Pamphlet No. 350-30, August 1975.

U.S. Department of the Army. Toward a New Hand Gun. Army Research, Development and Acquisition Magazine, Alexandria, VA: Hq., U.S. Army Materiel Development and Readiness Command, January-February 1981.

APPENDICES

APPENDIX A.

Examination of Design Subsystem Performance Potentialities Taxa to Assess Their Relevance to Evaluation of Learner Testing Specifications

a. "Identifying Goals and Priorities for Training" (Taxon 1.1)

1.1.1.1 "Identifying types of achievements relevant to the intended job."

The job-relevant achievements ultimately represent the subject matter of learner testing. The single most important reason for testing learners is to determine whether they are ready to do the job for which they have been trained. If the Design subsystem does not have the capability of identifying accurately the job-relevant achievements, the testing specifications almost certainly will be deficient. If important achievements are overlooked in the training design, they will also not be covered by any specified test. If non-relevant achievements are included in the training design, then corresponding non-relevant tests will be included in the specification. In either case the tests specified would produce distorted images of learners' qualifications for the job.

Conclusion: <u>This taxon is relevant to the measurement application</u>.

Note that this conclusion automatically insures the relevance of taxon 1.1.1 ("Defining the total scope of learning") and taxon 1.1 ("Identifying goals and priorities").

1.1.1.2 "Analyzing achievements to determine suitability for training."

The testing specifications must include provisions for assessing the candidate job performer's abilities relative to <u>every</u> achievement deemed relevant to the job. This is true of <u>all</u> achievements that are selected as suitable for training. It is <u>equally</u> true of those achievements deemed not suitable for training: those become cast as prerequisites for the job. It is just as necessary to know whether a prospective learner possesses the prerequisites as it is to know whether the learner has achieved the abilities addressed in training. The Design subsystem's capabilities for assessing whether or not a job-relevant achievement is suitable for training will have a major impact on the subsystem's performance in specifying learning content. It should not affect the system's performance in specifying testing. Of course, if the content is poorly analyzed, the tests probably will disclose that the training fails to qualify learners as job performers.

Conclusion: This taxon is <u>not</u> relevant to the application.

1.1.2.1 "Determining necessary levels of achievement."

Learner testing is supposed to disclose not only whether the candidate job performer can carry out the actions relevant to the job, but also whether he or she can do so well enough to meet the job's requirements. For example, some job might require a performer to lift a 50-lb. weight and hold it at shoulder height for a period of time. It would be critical for training design, personnel selection, and learner testing to determine whether that "period of time" is instantaneous, a few seconds, several minutes, or whatever. If the job's requirements called for holding the weight for, say, 15 seconds, it would be inappropriate to test the learner by requiring that he or she hold it for only 5 seconds; it would be equally wrong to conduct a test that required holding the weight for a full minute. The former test would "qualify" some learners who actually do not meet job requirements; the latter test would "disqualify" some who can really do the job. Thus, a Design subsystem that is not capable of accurately determining necessary levels of achievement very likely will produce test specifications that are deficient.

Conclusion: This taxon is relevant to the application.

Note that this insures as well the relevance of taxon 1.1.2 ("Stating the ultimate intended outcomes of learning").

1.1.2.2 "Determining existing levels of achievement."

This capability explicitly calls for testing. It requires that the current status of the candidate learner populations' abilities relevant to the job be determined. This implies that at least some testing, even if only informal, be applied to at least some representatives of those populations.

Conclusion: This taxon is relevant to the application.

1.1.2.3 "Discerning discrepancies between existing and necessary levels of achievement."

This requirement pertains to the Design subsystem's ability to accurately assess differences between what the populations of candidate job performers can do now, and what they need to be able to do to perform the job satisfactorily. That ability demands access to data that can be acquired through testing, and demands the subsystem's ability to apply those data correctly. But, it has no direct bearing on the test specifications themselves.

Conclusion: This taxon is not relevant to the application.

1.1.3.1 "Assessing goal importance."

The absolute or relative importance of the various training goals have no impact on the need to test <u>all</u> achievements relevant to the job.

Conclusion: This taxon is <u>not</u> relevant to the application.

1.1.3.2 "Insuring availability of a relative (numeric) goal ranking scheme."

The comment given under taxon 1.1.3.1 also applies here.

Conclusion: This taxon is <u>not</u> relevant to the application.

1.1.4.1 "Insuring availability of a hierarchy/taxonomy of goals."

A Design subsystem must be able to classify its training goals and objectives in a way that permits the kinds of actions required of learners and job performers to be identified accurately. This is of particular significance to test specification, for without a suitable classification scheme, the wrong type of test might be specified. For example, if an objective requires a learner to demonstrate some physical act, it would not be sufficient to test the learner's achievement of that objective only by requiring him or her to <u>state</u> the physical activity. That test would disclose whether the learner knows what is needed, but it wouldn't disclose whether the learner can really do what is needed.

Conclusion: <u>This taxon is relevant to the application</u>.

Note that taxon 1.1.4 ("Establishing a basis for specifying performance objectives") is thus also relevant.

1.1.4.2 "Stating goals in terms that imply behaviors."

If a Design subsystem is unable to state its training goals in behaviorally relevant terms, it is unlikely that the actions required of learners will be identified correctly or expressed in a fashion insuring they will be observable and quantifiable. If the required actions are unclear, then the actions to be tested also will be unclear. Proper test specification demands behaviorally defined goals and objectives.

Conclusion: <u>This taxon is relevant to the application</u>.

b. "Establishing Performance Objectives" (Taxon 1.2)

1.2.1.1 "Defining the performance action."

If action cannot be precisely defined, then the learner's ability to produce the action cannot be exercised in a test.

Conclusion: This taxon is relevant to the application.

Note that taxa 1.2.1 ("Stating what learners will be able to do or how they will be expected to behave after completing training") and 1.2 ("Establishing performance objectives") automatically are relevant as well.

1.2.1.2 "Defining the performance conditions."

If the performance conditions required for performing the action on the job cannot be precisely defined, then no assurance can be had that the specified tests will exercise the learner's ability under the appropriate set of circumstances.

Conclusion: This taxon is relevant to the application.

1.2.1.3 "Defining the performance standard."

If the standard for "good enough" performance cannot be precisely defined, the test specifications likely will not provide for accurate interpretation of the adequacy of the learner's action.

Conclusion: This taxon is relevant to the application.

1.2.2.1 "Developing pre-test items."

Pre-test items form an integral portion of the test specifications.

Conclusion: This taxon is relevant to the application.

Thus, taxon 1.2.2 ("Providing a basis for objectively assessing learner performance") also is relevant.

1.2.2.2 "Developing post-test items."

Post-test items form an integral portion of the test specifications.

Conclusion: This taxon is relevant to the application.

c. "Analyzing Performance Objectives" (Taxon 1.3)

1.3.1.1 "Revealing present conditions of learning."
1.3.1.2 "Identifying essential prerequisites."
1.3.1.3 "Identifying supportive prerequisites."

Test specifications must provide for diagnosing the cause of any deficiency in a learner's performance. Such deficiencies might arise because a learner fails to accomplish some prerequisite to a given objective. For example, the learner may fail to recall something that is relevant to learning (a deficiency in the present conditions of learning); or the learner may not

have mastered some achievement that is an essential milestone toward the objective (a deficiency in an essential prerequisite); or the learner may not have mastered some achievement that, while not essential for the objective, would have facilitated attainment of the objective (a deficiency in a supportive prerequisite). Unless these types of prerequisites can be identified, they won't be reflected in the test specifications.

Conclusion: These three taxa are all relevant to the application.

Note, therefore, that taxon 1.3.1 ("Identifying prerequisites to learning") and taxon 1.3 ("Analyzing performance objectives") also are relevant.

1.3.2.1 "Developing entry test items."

Entry test items form an integral portion of the test specifications.

Conclusion: This taxon is relevant to the application.

Taxon 1.3.2 ("Providing a basis for objectively assessing a candidate learner's suitability) thus also is relevant to the application.

1.3.3.1 "Discerning independence between objectives."
1.3.3.2 "Discerning dependency between objectives."
1.3.3.3 "Discerning a supportive relationship between objectives."

These potentialities express the capability that the Design subsystem must have for determining the sequence in which performance objectives should be achieved during training. Certain objectives logically must be achieved before others are pursued. In other cases, the achievement of a given objective will aid a learner's pursuit of another objective even though it is not essential for that pursuit. The Design subsystem must have the capability of identifying these dependency relationships if it is to structure the training efficiently and effectively. However, the dependency among objectives really has no direct bearing on the testing of those objectives.

Conclusion: These three taxa are not relevant to the application.

1.3.4.1 "Identifying information type objectives."
1.3.4.2 "Identifying mental skills type objectives."
1.3.4.3 "Identifying physical skills type objectives."
1.3.4.4 "Identifying attitude type objectives."

The comment given above in reference to taxon 1.1.4.1 is applicable here as well. Unless the Design subsystem can accurately classify its performance objectives in terms of the type of learning called for, the test specifications may not

insure that the proper type of testing takes place. Measurement of a learner's achievement of a mental skills objective, for instance, requires a mental skills test; achievement of a physical skills objective must be measured by a physical skills text; and so forth.

Conclusion: These four taxa are relevant to the application.

Note that taxon 1.3.4 ("Classifying objectives in terms of the domains of learning involved") automatically is relevant as well.

1.3.5.1 "Identifying overt steps."
1.3.5.2 "Identifying covert steps."
1.3.5.3 "Identifying unconscious steps."

The Design subsystem must have the capability of analyzing the actions required of the performance objectives to identify the constituent steps that make up the action. This is essential for structuring the training content in a way that fully explains each task to the learners, and that enables the learner to practice performing the task. The capability is also essential for insuring proper testing of learners, since the testing should diagnose performance deficiencies. In other words, if a learner fails in performing a task on which he or she is being tested, it should be possible to determine which of the overt, covert, or unconscious steps led to the failure. This is a significant challenge to the test designer, since he or she must devise ways to translate the covert and unconscious steps into observable, quantifiable behaviors. This often requires that the learner-being-tested state aloud the results of mental processes, decisions, recognitions, etc., that proceed in silence under normal on-the-job conditions. But certainly, the test designer cannot develop means of diagnosing the learner's performance of the constituent steps unless those steps can be identified.

Conclusion: These three taxa are relevant to the application.

Note that taxon 1.3.5 ("Identifying component steps or processes within the objectives") automatically is relevant as well.

d. "Defining Training Content" (Taxon 1.4)

1.4.1.1 "Defining propositions, names, facts, etc., that are relevant to information objectives."

This capability is essential to insure that the Design subsystem can accurately select the content to be provided to learners to assist them in achieving information-type objectives. This is an extremely critical capability bearing on how well the

subsystem specifies the learner presentation/demonstration activities. However, how the learner learns is of no real significance to the specification of means for determining whether the learner has learned. Indeed, test designers often err by producing test specifications that measure how well the learner recalls his or her learning experiences and the material to which he or she was exposed rather than measuring how well the learner has achieved the stated objectives. If the instructional content provided to support a given information-type objective was poorly chosen, the tests specified for that objective probably will disclose widespread performance deficiencies among learners. But the central fact is that the objectives-referenced tests should be independent of the instructional content.

Conclusion: This taxon is not relevant to the application.

1.4.1.2 "Defining concepts, rules, algorithms, etc., relevant to mental skills objectives."
1.4.1.3 "Defining movements, timings, actions, etc., relevant to physical skills objectives."
1.4.1.4 "Defining values, choices, etc., relevant to attitude objectives."

The comments given above in reference to taxon 1.4.1.1 apply here as well.

Conclusion: These three taxa are not relevant to the application.

1.4.2.1 "Assessing applicability of Job Performance Aids."
1.4.2.2 "Assessing applicability of Self-Teaching Exportable Packages."
1.4.2.3 "Assessing applicability of Formal On-the-job Training."
1.4.2.4 "Assessing applicability of Installation Support School."
1.4.2.5 "Assessing applicability of Resident School."

The Design subsystem must possess these five capabilities if it is to do a proper job in choosing the settings for the various learning activities. However, the issue of where training takes place has no bearing on the specification of tests to determine whether the training was successful.

Conclusion: These five taxa are not relevant to the application.

1.4.3.1 "Sequencing in dependency order."
1.4.3.2 "Sequencing in supportive relationship (efficiency) order."

The Design subsystem must possess these capabilities to insure that the performance objectives will be pursued in a logical, efficient sequence. That is absolutely essential if the learning experiences are to be as effective as possible. But the order in which objectives are pursued should have no bearing on the tests to be used to determine whether the objectives are met.

Conclusion: These two taxa are not relevant to the application.

e. "Defining Training Procedures" (Taxon 1.5)

1.5.1.1 "Defining facilitator preparation activities."
1.5.1.2 "Defining facilities preparation requirements."
1.5.1.3 "Defining attention gaining procedures."
1.5.1.4 "Defining objective-informing procedures."
1.5.1.5 "Defining procedures for stimulating learners' recall of prerequisites."

All of these capabilities must be present in the Design subsystem if it is to be able to specify appropriate and efficient means of assisting learners to prepare for learning. However, none of these capabilities bear on the subsystem's work in specifying appropriate means of testing learners.

Conclusion: These five taxa are not relevant to the application.

1.5.2.1 "Defining presentation media/media alternatives."
1.5.2.2 "Defining procedures and requirements for placing emphasis."
1.5.2.3 "Defining procedures for enhancing learners' comprehension and retention."

All of these capabilities must be present in the Design subsystem if it is to be able to specify appropriate and efficient means of presenting/demonstrating the training content and material to the learners. However, none of these capabilities bears on the subsystem's work in specifying appropriate means of testing learners.

Conclusion: These three taxa are not relevant to the application.

1.5.3.1 "Defining procedures for enhancing learners' participation/involvement."
1.5.3.2 "Defining procedures for eliciting the performance from learners."
1.5.3.3 "Defining procedures for providing learning guidance to learners."

These three capabilities must be present in the Design subsystem if it is to be able to specify appropriate and efficient means of assisting the learners to practice/apply what they are learning. However, none of these capabilities bears on the subsystem's work in specifying appropriate means of testing learners.

Conclusion: These three taxa are not relevant to the application.

1.5.3.4 "Defining procedures for providing learning feedback to learners."

1.5.3.5 "Defining procedures for assessing sufficiency of practice."

The two capabilities also are essential to insure that the Design subsystem will be able to specify appropriate and efficient practice for the learners. The key ingredient that these capabilities supply is learner feedback, i.e., the ability to inform the learner of how he or she is doing in practice, and to help the learner and facilitator judge whether the learner has practiced enough, at least for the time being. These abilities demand some form of testing. Usually, this is learner self-testing, perhaps under observation and "scoring" by a facilitator.

Conclusion: <u>These two taxa are relevant to the application</u>.

Note that this automatically implies that taxon 1.5.3 ("Specifying application procedures") and taxon 1.5 ("Defining training procedures") also are relevant.

1.5.4.1 "Defining procedures to assess the proper domain of learning."

This capability aims at one key ingredient of learner testing, namely, the ability to insure that the proper kinds of tests are used for a given class of learning objectives.

Conclusion: <u>This taxon is relevant to the application</u>.

Note that taxon 1.5.4 ("Specifying learner evaluation procedures") therefore is relevant as well.

1.5.4.2 "Defining procedures to assess the appropriate action/behavior."

This capability goes to the heart of another key ingredient of learner testing, namely, the ability to insure that the tests require the learner to demonstrate the actions that are appropriate for the performance objectives.

Conclusion: <u>This taxon is relevant to the application</u>.

1.5.4.3 "Defining procedures to insure assessment reliability."

This capability focuses on yet another key ingredient of learner testing, namely, the ability to insure that the tests are conducted subject to conditions and performance standards that reflect real job requirements.

Conclusion: <u>This taxon is relevant to the application</u>.

f. "Evaluating the Curriculum" (Taxon 1.6)

1.6.1.1 "Entry-level testing of representative candidate learners."

In order to validate the assumptions underlying the curriculum, the Design subsystem must be able to ascertain whether the candidate learner populations actually satisfy the prerequisites specified for the training. Usually, if not always, this entails some type of testing of at least some representative members of those populations. The ability to construct and apply such tests is an ingredient of the subsystem's overall performance in specifying learner testing.

Conclusion: <u>This taxon is relevant to the application</u>.

Note that this implies that taxa 1.6.1 ("Validating/revising the bases for the developing curriculum") and 1.6 ("Evaluating the curriculum") also are relevant.

1.6.1.2 "Post-training testing of representative job incumbents."

The training is supposed to prepare the learners to do the job for which the training was designed. Post-training tests specified by the Design subsystem are supposed to provide a basis for determining whether the learners are in fact prepared to do the job. The post-tests, in other words, are supposed to predict job performance. Whenever possible, it is desirable to validate the post-tests by applying them to current (satisfactory) job incumbents. The ability to do so clearly is an ingredient of the subsystem's overall performance in specifying learner testing.

Conclusion: <u>This taxon is relevant to the application</u>.

1.6.2.1 "Obtaining error data."

One key question to be faced at the final stages of a curriculum development effort is: "Given a group of learners who have received training in accordance with the curriculum, how well do those learners perform?" Part of the answer is found by administering specified post-tests to a sample of (pilot test) learners. Such testing produces error data, disclosing which objectives or portions of objectives were not achieved by significant numbers of learners. The ability to obtain this error data is an ingredient of the subsystem's overall performance in specifying learner testing.

Conclusion: <u>This taxon is relevant to the application</u>.

Note that taxon 1.6.2 ("Validating/revising the developing curriculum itself") thus also is relevant.

1.6.2.2 "Obtaining design feedback."

Design feedback consists of general and specific criticisms of the curriculum by representative "users" of the curriculum, i.e., learners and facilitators. Like error data, design feedback typically is obtained in pilot-test settings, often at virtually the same time that learner post-testing occurs. However, the solicitation of design feedback is not a test, nor is it in any way part of the curriculum's test specifications.

Conclusion: This taxon is not relevant to the application.

1.6.2.3 "Correlating post-test data with subsequent job performance."

The ultimate evaluation of a new curriculum is found in the learners' job performance subsequent to training. The Design subsystem must have the capability of obtaining measures on job performance, at least for a sample of "graduated" learners. Further, it must be able to compare those measures with the end-of-training tests administered to the same learners, to identify any deficiencies in the test specifications. The test specifications cannot be considered to be "complete" if the ability to correlate test results with real job performance is not built into the Design subsystem.

Conclusion: This taxon is relevant to the application.

APPENDIX B.

Application of the APM (Measurement) to the IFV Training System

Appendix B supports the textual material presented in Section III of this report. It contains Figures B1 through B10. Briefly, Figures B1 through B6 present all of the Army Handgun Training Design Subsystem Potentialities Requirements. Figure B7 illustrates a sample AHTDS Performance Process Requirements, and Figure B8 illustrates an example of the process design specifications for the Figure B7 requirements. Similarly, Figure B9 illustrates a sample AHTDS Performance Product Requirements, and Figure B10 illustrates an example of the product design specifications for the Figure B9 requirements.

Performance Potentiality Hierarchy Number 1: The capability of identifying training goals and priorities

1.1
The Handgun Training Design Subsystem must possess the ability to identify training goals and priorities for all intended military users and uses of the handgun.

1.1.1
Given a list of handgun users and uses, the Design Subsystem must be able to define the scope of learning needed for each handgun user/use in terms of the knowledge, skills, and attitudes required.

1.1.1.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify, for each handgun user/use, exactly what the user must know; exactly what skills the user must possess; and exactly what attitudes the user must manifest.

1.1.1.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to analyze the identified knowledge, skills, and attitudes to determine their suitability for training.

1.1.2
Given a list of handgun users and uses, the Design Subsystem must be able to define what each user ultimately will be able to do with the handgun, in training goal terms.

1.1.2.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define the necessary levels of performance achievements that each handgun user must manifest in order to apply the handgun to its intended uses.

1.1.2.2
The Handgun Training Design Subsystem must demonstrate that it is able to determine correctly the pre-training levels of the relevant performance achievements possessed by members of the intended handgun user populations.

1.1.2.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to discern correctly the discrepancies existing between current and required levels of relevant performance achievements within the intended handgun user populations.

1.1.3
Given a list of handgun users and uses, and given the training goals defined for each user/use, the Design Subsystem must be able to identify the relative importance of each defined goal.

1.1.3.1
The Handgun Training Design Subsystem must demonstrate that it has the ability to formulate assessments of training goal importance.

1.1.3.2
The Handgun Training Design Subsystem must demonstrate that it can devise or select a suitable scheme for ranking the relative importance of its training goals.

1.1.4
Given a list of handgun users and uses, and given the training goals defined for each user/use, the Design Subsystem must be able to express the goals in behaviorally oriented terms to establish a basis for identifying handgun user performance objectives.

1.1.4.1
The Handgun Training Design Subsystem must demonstrate that it can devise or select a suitable taxonomy of goals/objectives to be used to classify its intended training outcomes.

1.1.4.2
The Handgun Training Design Subsystem must demonstrate that it is capable of stating its goals in terms that permit the necessary user behaviors to be identified.

Figure B-1. Army Handgun Training Design Subsystem Performance Requirements Basic Potentialities Needed: Hierarchy Number 1

Performance Potentiality Hierarchy Number 2:
The capability of establishing performance objectives

1.2
The Handgun Training Design Subsystem must possess the ability to establish performance objectives for all intended military users and uses of the handgun.

1.2.1
Given a list of handgun users and uses, the Design Subsystem must be able to state in performance-oriented terms what the handgun users will be able to perform as a result of training.

1.2.1.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define all of the tasks that the handgun users will be expected to perform.

1.2.1.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define all of the conditions/circumstances under which each of the tasks is to be performed.

1.2.1.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define all of the training/performance standards for each task and for all of the conditions under which the task is to be performed in terms of minimum acceptable proficiency.

1.2.2
Given a list of handgun users and uses and given the stated performance objectives, the Design Subsystem must be able to define a scheme for objectively assessing handgun user performance prior to and after receiving the designed training.

1.2.2.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to develop pre-test items to determine handgun users' existing knowledges, skills and attitudes.

1.2.2.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to develop post-test items to determine handgun users' post-training knowledges, skills and attitudes.

Figure B-2. Army Handgun Training Design Subsystem Performance Requirements Basic Potentialities Needed: Hierarchy Number 2

Performance Potentiality Hierarchy Number 3: The capability of analysing performance objectives

1.3
The Handgun Training Design Subsystem must possess the ability to analyse the performance objectives for all intended military users and uses of the handgun.

1.3.1
Given a list of handgun users and uses, the Design Subsystem must be able to identify the prerequisites to learning, i.e., exactly what learning must be exhibited by the intended users in order to achieve the performance objectives.

1.3.1.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to analyse the present conditions of learning and identify the knowledges intended handgun users must recall.

1.3.1.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to analyse performance objectives to identify essential prerequisites for achieving each performance objective.

1.3.1.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to analyse performance objectives to identify the objective's supportive "enabling" prerequisites.

1.3.2
Given a list of handgun users and uses, the Design Subsystem must be able to define a scheme/basis for objectively assessing a potential handgun user's suitability for training.

1.3.2.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to develop entry-level test items of potential handgun users' existing skills, knowledges and attitudes, i.e., what the potential users bring to the training situation.

1.3.3
Given a list of handgun users and uses, the Design Subsystem must be able to identify the interactional/dependence among performance objectives.

1.3.3.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to analyse and identify those performance objectives that are independent (stand alone).

1.3.3.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to discern/identify dependence between performance objectives.

1.3.3.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to discern/identify supportive relationships that may exist between performance objectives.

1.3.4
Given a list of handgun users and uses, the Design Subsystem must be able to categorize/classify each handgun performance objective in terms of the associated domains of learning.

1.3.4.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify all performance objectives considered to be "information" type objectives.

1.3.4.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify all performance objectives considered to be "mental skill" type objectives.

1.3.4.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify all performance objectives considered to be "physical skill" type objectives.

1.3.4.4
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify all performance objectives considered to be "attitude" type objectives.

1.3.5
Given a list of handgun users and uses, the Design Subsystem must be able to analyse each performance objective to identify the required overt/covert behaviors.

1.3.5.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify those performance objectives which contain overt (discernible) steps.

1.3.5.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify those performance objectives which contain covert behaviors.

1.3.5.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to identify those performance objectives which contain unconscious (without cognition) behaviors.

Figure B-3. Army Handgun Training Design Subsystem Performance Requirements Basic Potentialities Needed: Hierarchy Number 3

Performance Potentiality Hierarchy Number 4: The capability of defining the training content

1.4
The Handgun Training Design Subsystem must possess the ability to define the handgun training content required to achieve the users' performance objectives.

1.4.1
Given a list of handgun users and uses, and given the defined training goals and analyzed performance objectives, the Design Subsystem must be able to select stimuli for each performance objective relevant to the domains of learning.

1.4.1.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures, facts, names, etc., that are relevant to information-type objectives.

1.4.1.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define concepts, rules, algorithms, etc., relevant to mental skills objectives.

1.4.1.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define handgun user/user movements, actions, timings, etc., for relevant physical skill objectives.

1.4.1.4
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define handgun user/user choices, values, etc., relevant to attitude objectives.

1.4.2
Given a list of handgun users and uses, and given the defined training goals and analyzed performance objectives, the Design Subsystem must be able to select an appropriate instructional setting for each performance objective.

1.4.2.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to assess the applicability of Job Performance Aids (JPAs) to enhance the learning process.

1.4.2.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to assess the applicability of Self-Teaching Exportable Packages (STEPs) as a vehicle to enhance the learning process.

1.4.2.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to assess the applicability of formal on-the-job training (OJT).

1.4.2.4
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to assess the applicability of Installation Support Schools (ISS) as a possible instructional setting.

1.4.2.5
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to assess the applicability of Resident Schools (RS) as a possible instructional setting.

1.4.3
Given a list of handgun users and uses, and given the defined training goals and analyzed performance objectives, the Design Subsystem must be able to define an instructional sequence which provides for the optimum transition and support from one performance objective to another.

1.4.3.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to sequence the training relative to the objectives dependency order of required skills, knowledges and attitudes.

1.4.3.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to sequence the training based upon the supportive order of knowledges, skills and attitudes from one performance objective to other performance objectives.

Figure B-4. Army Handgun Training Design Subsystem Performance Requirements
Basic Potentialities Needed: Hierarchy Number 4

Performance Potentiality Hierarchy Number 5: The capability of defining training procedures

1.5
The Handgun Training Design Subsystem must possess the ability to define the training procedures to be employed for all intended military users and uses of the handgun.

1.5.1
Given a list of handgun users and uses, and given the training goals and priorities, analyzed performance objectives and defined training content, specify the training preparation procedures required to assure optimum learning.

1.5.1.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define required teacher preparation activities to assure optimum learning.

1.5.1.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define facilities preparation requirements to accomplish handgun training objectives.

1.5.1.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define handgun learner attention-gaining procedures.

1.5.1.4
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define handgun performance objective-informing procedures.

1.5.1.5
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures for stimulating handgun learner's recall of handgun training prerequisites.

1.5.2
Given a list of handgun users and uses, and given the training goals and priorities, analyzed performance objectives, and defined training content, specify the training presentation procedures required to assure optimum learning.

1.5.2.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define presentation media/media alternatives to assure optimum learning.

1.5.2.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define presentation procedures and requirements for placing emphasis to enhance the need-to-learn.

1.5.2.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define learning procedures to enhance handgun learner's comprehension and retention.

1.5.3
Given a list of handgun users and uses, and given the training goals and priorities, analyzed performance objectives, and defined training content, specify the application procedures required to assure optimum trainee achievement of performance objectives.

1.5.3.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define training application procedures for enhancing the handgun learner's involvement or participation in the handgun training.

1.5.3.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures which will enhance/stimulate learner performance.

1.5.3.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures that will provide learning guidance to handgun learners.

1.5.3.4
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures which will assure that learning feedback is provided to handgun learners.

1.5.3.5
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures which assure that adequate/sufficient practice has been accomplished to consistently achieve performance objectives.

1.5.4
Given a list of handgun users and uses, and given analyzed performance objectives and defined training content, specify evaluation procedures to assure achievement of performance objectives.

1.5.4.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures to assess the learner's achievement of information, mental skills, physical skills and attitude objectives, i.e. the domains of learning

1.5.4.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures for assessing appropriate handgun learner behavior action.

1.5.4.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to define procedures that will assure reliable assessment of handgun learner achievement of performance objectives.

Figure B-5. Army Handgun Training Design Subsystem Performance Requirements
Basic Potentialities Needed: Hierarchy Number 5

Performance Potentiality Hierarchy Number 6:
The capability of evaluating the curriculum

1.6
The Handgun Training Design Subsytem must possess the ability to evaluate the curriculum developed for intended Army users and uses of the handgun.

1.6.1
Given a list of handgun users and uses, as well as defined handgun training system goals and priorities, defined performance objectives, defined training content and training procedures, the Design Subsystem must be able to validate and/or revise the bases for developing the handgun training system curriculum.

1.6.1.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to conduct entry-level testing of representative handgun learners.

1.6.1.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to conduct post-training testing of representative handgun users.

1.6.2
Given a list of handgun users and uses, as well as defined handgun training system goals and priorities, defined performance objectives, defined training content and training procedures, the Design Subsystem must be able to validate/revise the developing handgun curriculum itself.

1.6.2.1
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to obtain error data related to trial learner training.

1.6.2.2
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to obtain curriculum design feedback from potential learners/job incumbents.

1.6.2.3
The Handgun Training Design Subsystem must demonstrate that it possesses the ability to correlate post-test training data with subsequent learners' job performance.

Figure B-6. Army Handgun Training Design Subsystem Performance Requirements Basic Potentialities Needed: Hierarchy Number 6

Performance Processes Hierarchy Number 3: An approach for analyzing tasks selected for training

2.3
The Handgun Training Design Subsystem must be able to plan an approach for analyzing handgun user tasks which are selected for training.

2.3.1
Utilizing the job analysis of handgun users and uses and an assessment of those handgun users' tasks selected for training development, the Design Subsystem must be able to plan an approach to identify the information processing entailed in each of the tasks selected for training.

2.3.1.1
The Handgun Training Design Subsystem must be able to plan an approach to analyze task decision flows to reduce processing to a sequence of binary decisions.

2.3.1.2
The Handgun Training Design Subsystem must be able to plan an approach to analyze the task decision levels in terms of nature, complexity, and time.

2.3.2
Utilizing the job analysis of handgun users and uses and an assessment of those handgun users' tasks selected for training development, the Design Subsystem must be able to plan an approach to classify the tasks selected for training in terms of the domains of learning involved.

2.3.2.1
The Handgun Training Design Subsystem must be able to plan an approach to identify knowledges which must be acquired.

2.3.2.2
The Handgun Training Design Subsystem must be able to plan an approach to identify the mental skills which must be acquired.

2.3.2.3
The Handgun Training Design Subsystem must be able to plan an approach to identify the physical skills which must be acquired.

2.3.2.4
The Handgun Training Design Subsystem must be able to plan an approach to identify attitudes to be acquired.

2.3.3
Utilizing the job analysis of handgun users and uses and the assessment of those handgun users' tasks selected for training development, the Design Subsystem must be able to plan an approach to identify the conditions for learning each of the tasks selected for training.

2.3.3.1
The Handgun Training Design Subsystem must be able to plan an approach to analyze information-processing requirements to identify prerequisite knowledge expected of learners.

2.3.3.2
The Handgun Training Design Subsystem must be able to plan an approach to analyze task requirements to identify prerequisite mental skills.

2.3.3.3
The Handgun Training Design Subsystem must be able to plan an approach to analyze the physical requirements to identify prerequisite motor skills.

2.3.3.4
The Handgun Training Design Subsystem must be able to plan an approach to analyze the attitudinal requirements to identify expected prerequisite learner attitudes.

Figure B-7. Army Handgun Training Design Subsystem Performance Requirements Basic Processes Needed: Hierarchy Number 3

Process Performance Requirement Number 3:
An approach for analyzing tasks selected for training

(2.3)

The AHT Command Subsystem will have reviewed as part of the curriculum design effort, the handgun user's job analysis and the analysis to determine which tasks should be selected for training development. The Design Subsystem will closely interact with the Command Subsystem in determining which of the tasks considered for training will actually be selected for training development. The final determination of tasks selected for training will be based on such factors as task training costs, available time and resources as well as tasks which may be already learned through previous training and consequently may be considered as a prerequisite to the AHT. Once the Design Subsystem has received the approved list of tasks to be trained they will be analyzed utilizing operational sequence diagram (OSD) techniques and decision trees which will describe in detail the learning hieiarchy associated with each task.

(2.3.1, 2.3.2, 2.3.3)

The team will examine the information processing entailed in each of the tasks selected for training in the context of representative scenarios designed specifically in the use of the handgun for personal defense actions. It is anticipated that the Command Subsystem will supply realistic scenarios in such detail to provide the analysts with information which describes the conditions and performance environment in which the user must utilize the handgun for self defense purposes. The sequential operations in performing each of the tasks will be analyzed via an OSD technique until all of the task elements and their required sub-elements have been defined. The analysis will identify all the handgun user task inputs, the processing required, the resulting outputs, as well as task element inter-relationships. At each level of task element analysis, the analyst will determine what information the learner must know, recall or state to perform the task. The analysis will identify categories of information which the potential handgun learner must process. These analyses also will be the basis for identifying prerequisite abilities that the handgun learner will bring to the training situation, as well as for identifying the learning the AHT must provide as described below.

Figure B-8. Sample Design Specifcation of a Process Aspect of the AHTDS
(In response to the Performance Requirements illustrated in Figure B-7.)

(2.3.1.1, 2.3.1.2)

The sequential analyses of tasks will identify handgun user decision flows. These decision flows will be further analyzed utilizing a binary decision tree (yes/no) technique. The decision flow analysis will include an appropriate time line as well as columns to identify the nature of decisions and to classify the complexity of the decision levels from simple to complex using a scale of 1 to 5. The complexity of these decisions will be based on such factors as criticality of the decision with regard to task completion delay tolerance and number of factors influencing the yes/no branches of the decision tree.

(2.3.2.1, 2.3.2.2, 2.3.2.3, 2.3.2.4)

The information-decision-action attribute model, described in detail in Section ** of this specification, will be the basis for performing the analyses to classify the tasks selected for training in terms of the domains of learning involved. An analysis of each of the tasks will be performed to develop categories of information the potential handgun learner must possess to complete tasks/task elements. The analysis will detail the bodies of knowledge the learners must be able to recall or state. To analyze mental skills required, the task elements will be analyzed in detail to determine rule learning and using, pattern recognition, symbol identification, detection cues and decision making. The team of analysts will prepare a detailed hierarchial documentation of the mental skills a potential learner must possess in the performance of tasks. To analyze physical skills required, again each task element will be sequentially analyzed to determine the sequence of physical (motor) skills required, a hierarchy of the sequence of physical skills required to perform required tasks will be fully documented. An analyses will also be performed to determine the attitudes a handgun learner should possess in performing the handgun systems functions i.e., serve as a short-term personal defense weapons system. This analysis will involve some speculative thinking since it is not always possible to observe attitudes directly. The team will analyze each task/task element and ask the question, "What would a potential handgun learner do if he had the desired attitude?" The team will use a consensus approach to develop a list of the attitudes potential learners must possess in order to exhibit the desired attitudes.

(2.3.3.1, 2.3.3.2, 2.3.3.3, 2.3.3.4)

The analyses to determine potential learner prerequisite knowledge, mental skills, physical skills, and attitudes will be accomplished utilizing the outputs of the analyses described in the previous paragraph and the analyses performed in Section ** which identifies entry-level behaviors that the potential learner brings to the learning situation. A comparison of entry level behaviors/attributes that a learner brings to the training situation and those behaviors/attributes that a trained handgun user must exhibit will define those knowledges, mental and physical skills as well as attitudes the learner must acquire via the AHT. The results of these analyses will be documented for each of the domains of learning.

Figure B-8 (Concluded)

Performance Products Hierarchy Number 3: The capability of producing lesson plans

3.3
The Handgun Training Design Subsystem must be able to produce lesson plans to support intended handgun user training objectives.

3.3.1
Utilizing the developed handgun user job analysis and performance objectives, the Design Subsystem must provide complete specification of the instructional content for each training objective.

3.3.1.1
The Handgun Training Design Subsystem must produce specifications of each handgun user training objective.

3.3.1.2
The Handgun Training Design Subsystem must produce specifications of assumed handgun learner prerequisites.

3.3.1.3
The Handgun Training Design Subsystem must produce an itemization of information topics.

3.3.1.4
The Handgun Training Design Subsystem must produce an itemization of mental skill steps.

3.3.1.5
The Handgun Training Design Subsystem must produce an itemization of physical skill steps.

3.3.1.6
The Handgun Training Design Subsystem must produce an itemization of learner attitudinal components.

3.3.1.7
The Handgun Training Design Subsystem must produce an itemization of practice exercises.

3.3.1.8
The Handgun Training Design Subsystem must produce an itemization of test problems/exercises.

3.3.2
Utilizing the developed handgun user job analysis and performance objectives, the Design Subsystem must provide complete specification of the instructional procedures for each training objective.

3.3.2.1
The Handgun Training Design Subsystem must produce specifications of procedures for preparing handgun learners to achieve each training objective.

3.3.2.2
The Handgun Training Design Subsystem must produce specifications of exactly how the instructional content topics/steps will be presented.

3.3.2.3
The Handgun Training Design Subsystem must produce specifications of exactly how the handgun learners will practice/apply the instructional content.

3.3.2.4
The Handgun Training Design Subsystem must produce specifications of exactly how the handgun learners will be tested on the instructional content.

3.3.2.5
The Handgun Training Design Subsystem must produce specifications of procedures for dealing with handgun learners who fail to demonstrate achievement of any of the training objectives.

3.3.3
Utilizing the developed handgun user job analysis and performance objectives, the Design Subsystem must provide complete specification of the instructional circumstances for each training objective.

3.3.3.1
The Handgun Training Design Subsystem must produce specifications of the location at which each instructional event will take place.

3.3.3.2
The Handgun Training Design Subsystem must produce specifications of the equipment needed to support the training.

3.3.3.3
The Handgun Training Design Subsystem must produce specifications of special location/equipment set-up/configuration requirements.

3.3.3.4
The Handgun Training Design Subsystem must produce specifications of instructional personnel needed.

3.3.3.5
The Handgun Training Design Subsystem must produce specifications of time and schedule requirements.

Figure B-9. Army Handgun Training Design Subsystem Performance Requirements
Basic Products Needed: Hierarchy Number 3

Product Performance Requirement Number 3:
The capability of producing lesson plans.

(3.3)

The team recognizes that the development of lesson plans is one of the most important requirements in the training development process. It is at this point that all of the preceding analyses will be utilized to produce the actual instructional products, i.e., lesson plans which support the AHT objectives. The team that has been assembled are well versed in producing lesson plans to meet these objectives. The analyses to develop the handgun user's job analysis and performance objectives will be the basis for lesson plan development. These analyses include the following information:

- Training objectives
- Tasks to be performed
- Conditions of performance
- Training standard of acceptable performance
- Test items for all objectives
- Reference to the task/task element from which the training objective was derived
- Training objective sequence number and how objectives were structured
- Learning category and sub-category for each training objective
- Learning activities for each objective
- Planning information from other AHT subsystems
- Existing handgun instructional programs

The team will use Field Manual 21-6 "Military Training" as a guide to produce lesson plans which provide practical, economical aid in preparing and delivering the training. The lesson plans will not be designed to record every word of the instructor's presentation. The following minimum information will be included in all of the produced lesson plans:

- The Training Objective(s)
- All Intermediate Training Objectives (if any) listed in the sequence to be taught
- Administrative instructions (as required)
  - When the training will be conducted
  - Training location
  - Who will be trained
  - Principal and assistant trainers
  - Training aids, devices and equipment to be used
  - References
- Training sequence and time estimate
- Safety restrictions
- Additional information required by local SOPs

Figure B-10. Sample Design Specification of a Product Aspect of the AHTDS.
(In response to the Performance Requirements illustrated in Figure B-9.)

(3.3.1, 3.3.2, 3.3.3)

In providing complete specifications of the instructional content, the team will prepare a content outline to satisfy each training objective. Each training objective will contain the tasks which must be learned, the conditions of task performance and the task standard of acceptable performance. The specifications will include learner prerequisites as well as the interim objectives which must be performed to achieve the objective. The outline will itemize the information topics, mental and physical skills, and attitudes which must be acquired as a result of learning. The lesson plans will include practical exercises and test items to stimulate learning as well as providing the instructors with criteria for evaluating trainee learning relative to the training objective. Instructional strategies will be included for each lesson plan. They will be in the form of guidelines and will offer strategies which will aid the instructor in presenting the material. The strategies will suggest ways to keep the learners involved. They will cue the instructor as to when instructional aids are appropriate as well as when to emphasize/repeat instructional material. The specifications for instructional circumstances will be detailed in the administrative instructions of the lesson plan as well as in the POI course guide.

(3.3.1.1 - 3.3.1.8)

The Task Inventory developed in Section ** of these specifications, will be used as the basis for deriving the specific terminal and intermediate Training Objectives. Each Training Objective will be clearly stated and will consist of the following three elements:

- Tasks - What knowledges/skills the handgun learners must acquire
- Conditions - Under what conditions the learners must acquire the knowledges/skills
- Training standard - A description of minimum acceptable performance

The various kinds of learned capabilities have various kinds of prerequisites--previously learned entities which are available from the learners memory at the time new learning begins. A notation of the type of prerequisite required for, or helpful to, the learning appropriate to each listed Training Objective will be identified. For each category of learned capability, the following will be considered:

Figure B-10 (Continued)

- Mental skill
  - Simpler component intellectual skills
- Physical skills
  - Part skills, procedural rules
- Verbal information
  - Meaningfully organized sets of information
- Cognitive Strategies
  - specific intellectual skills
- Attitudes
  - Intellectual skills, verbal information

To demonstrate how objectives in the various domains of learning interact with each other in reaching the final outcomes of the training objectives, the team will use the format titled "Instructional Maps." This map will show the teaching sequence and interactions for specific training objectives in the domains of information, intellectual skills, attitudes, cognitive strategies and motor skills as well as the relations of intermediate objectives within a single training objective. This itemization will help insure that all relevant content and skills are included in the training program.

To insure learning, sufficient practice time and exercises must be available. At a minimum, one practice exercise will be designed for each intermediate and training objective. To insure the transfer and integration of learning, the practice exercises will relate directly to the required job skills.

Means to evaluate learner achievement within each of the domains of learning will be itemized. The training objectives for the POI will be used as a basis for deriving test problems and exercises. In addition to itemizing the questions deemed essential, a few additional questions will be designed and included to check the reliability of responses and to measure the influence of changes in wording and teaching techniques. Two or more roughly equivalent or closely related questions (well-separated in the test) will be included in order to measure consistency (i.e., validity) of answers.

(3.3.2.1, 3.3.2.2, 3.3.2.3, 3.3.2.4)

Each lesson plan will specify the instructional strategies to be employed to meet both interim and training objectives. The strategies will be keyed to the lesson plan outline and serve to cue the instructor. Training content related to knowledge will present strategies to guide instructor-learner discussions. Skill related training (physical-mental) strategies will present cues to guide performance/practice oriented training. Attitude training cues will aid the instructor in presenting role

Figure B-10 (Continued)

plays, demonstrations or discussions. Each lesson plan will be designed so that the interim objectives are sequenced to provide a learning hierarchy to meet the training objective. Through performance oriented training the learners will apply the instructional content. The lesson plans will provide cues to the instructor to guide each phase of instructions. All tasks, conditions and standards will be presented as well as associated instructional strategies. Each training objective and associated interim/intermediate objectives will be tested against the stated task conditions and performance standards. A training record, keyed to the POI, will be designed as an aid to record learner achievement. Strategies will be provided on each lesson plan to guide remedial training.

(3.3.3.1, 3.3.3.2, 3.3.3.3, 3.3.3.4)

The team will insure that the administrative instructions on each lesson plan include the training facilities required to support the training, equipment needed to support the training, instructional personnel required and specifications of time. A training course guide will be developed to support required POI. The course guide will contain the following four sections:

- An Introduction, which will describe the Guide's organization, list the program's instructional units and provide an overview of the training administrator's responsibilities.

- A detailed discussion of the instructional program, including its overall objective(s), specific learner performance objectives and the contents and duration of each instructional unit.

- A detailed discussion of program planning considerations, including scheduling, desirable class size, instructor qualifications, materials and equipment required, facilities needed and procedures for estimating program costs.

- A detailed discussion of program management and evaluation considerations, including suggestions for record keeping and identification of potential improvements to the program.

Figure B-10 (Concluded)

APPENDIX C.

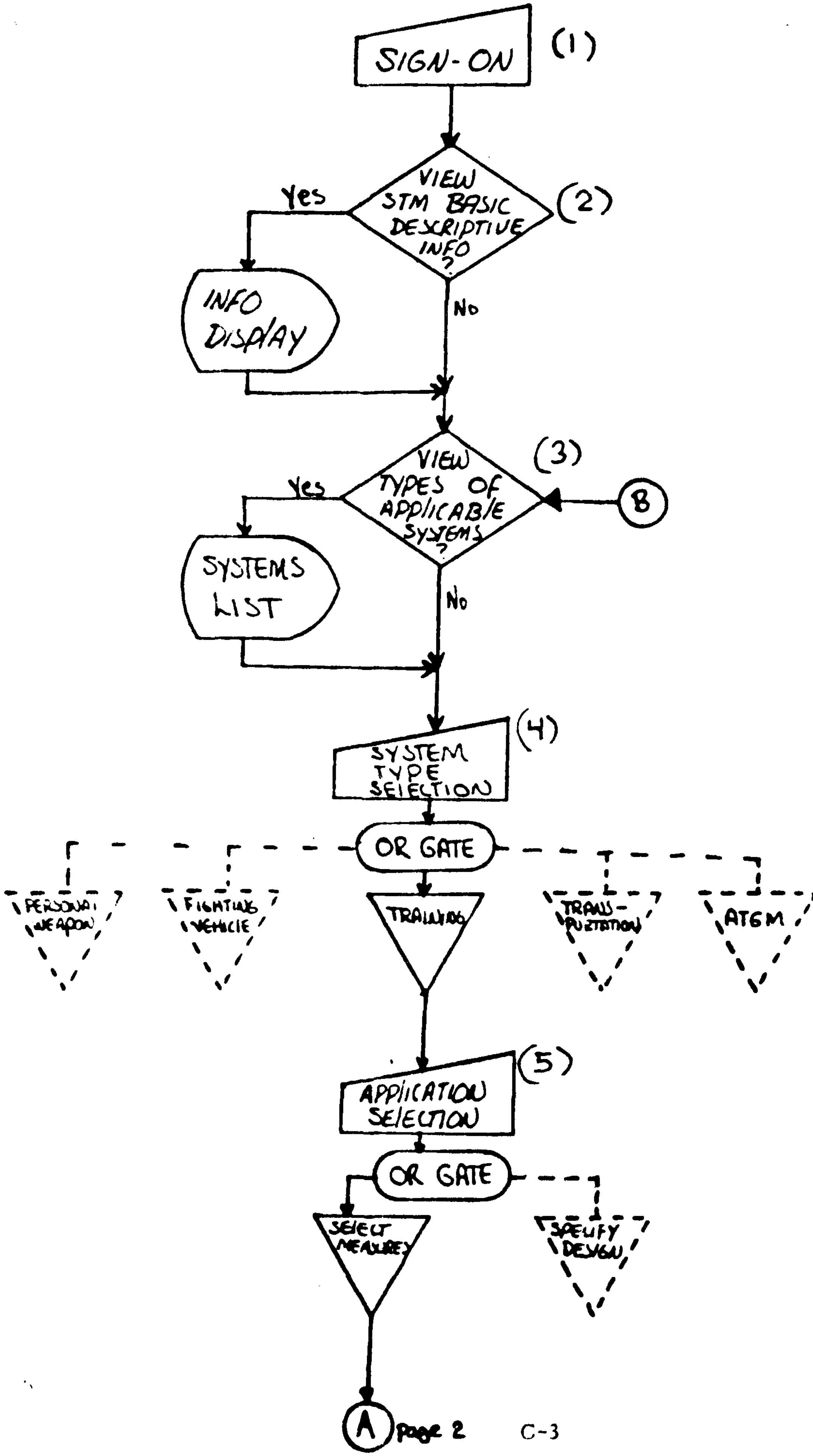
Documentation for the Computer-Aided Model

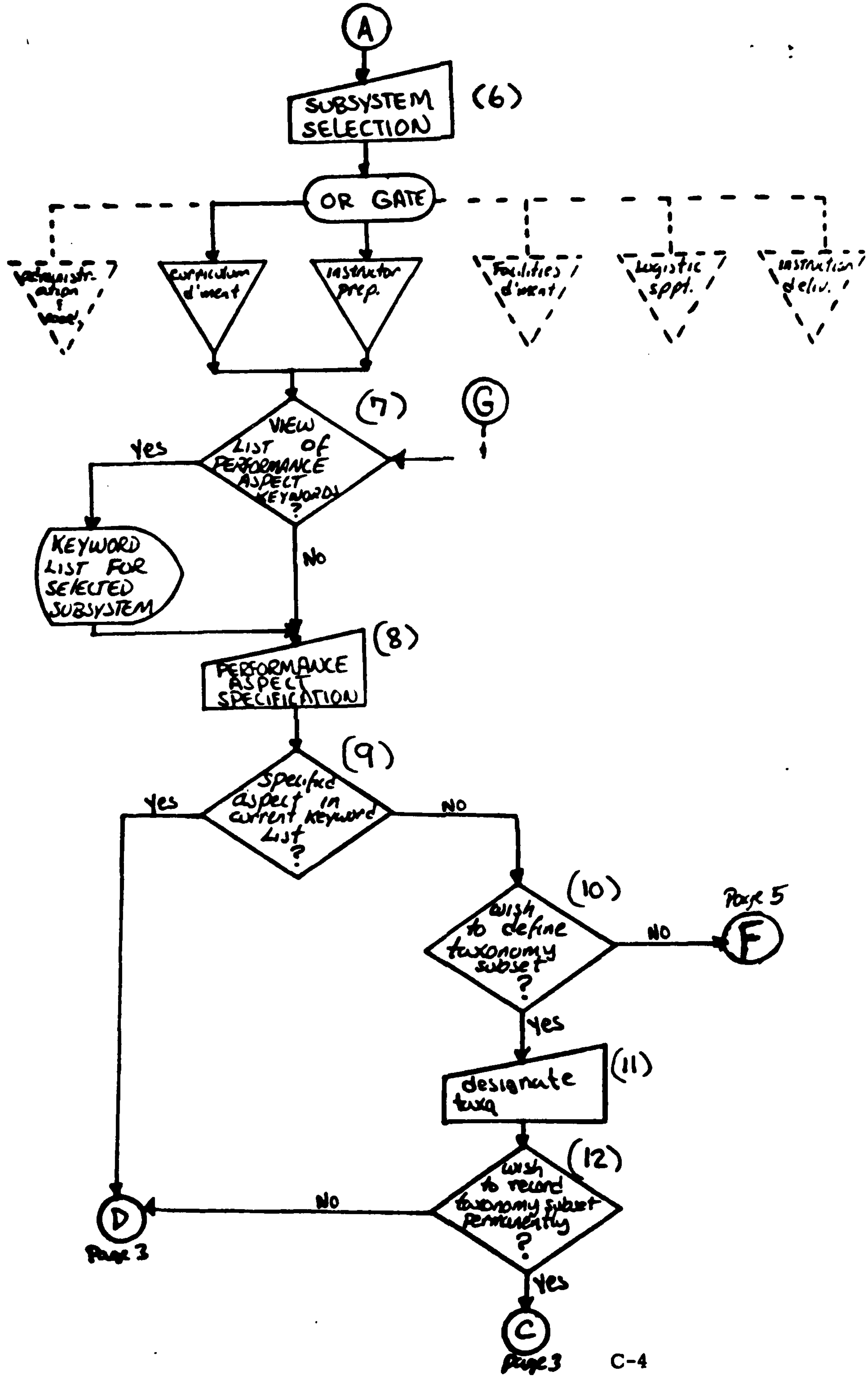
- General Flow Chart for Sample Demonstration Program
- Explanatory Notes for Flow Chart

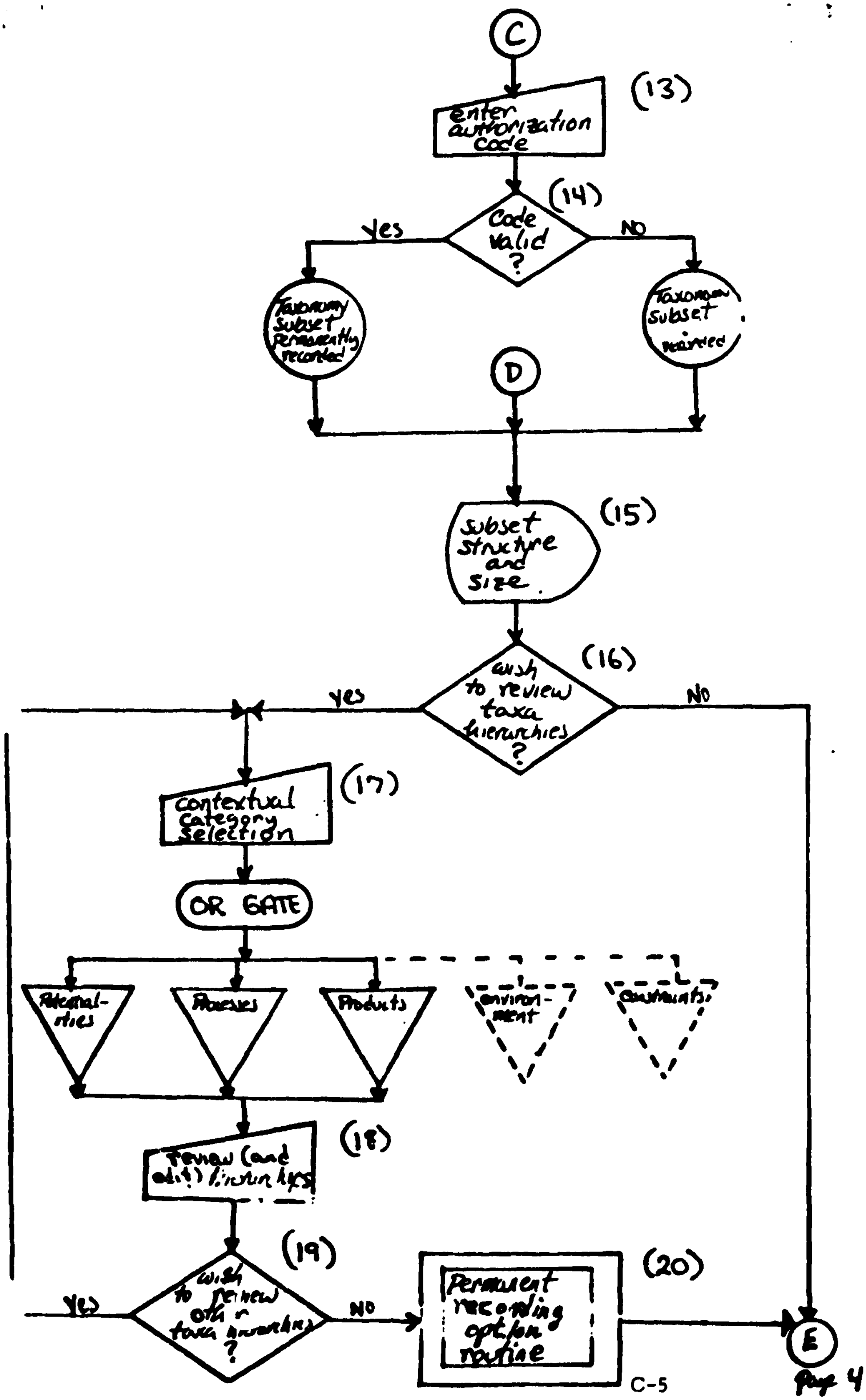
General Flow Chart for Sample Demonstration Program

Application of the APM for Developing Measures of the following Training Systems components:

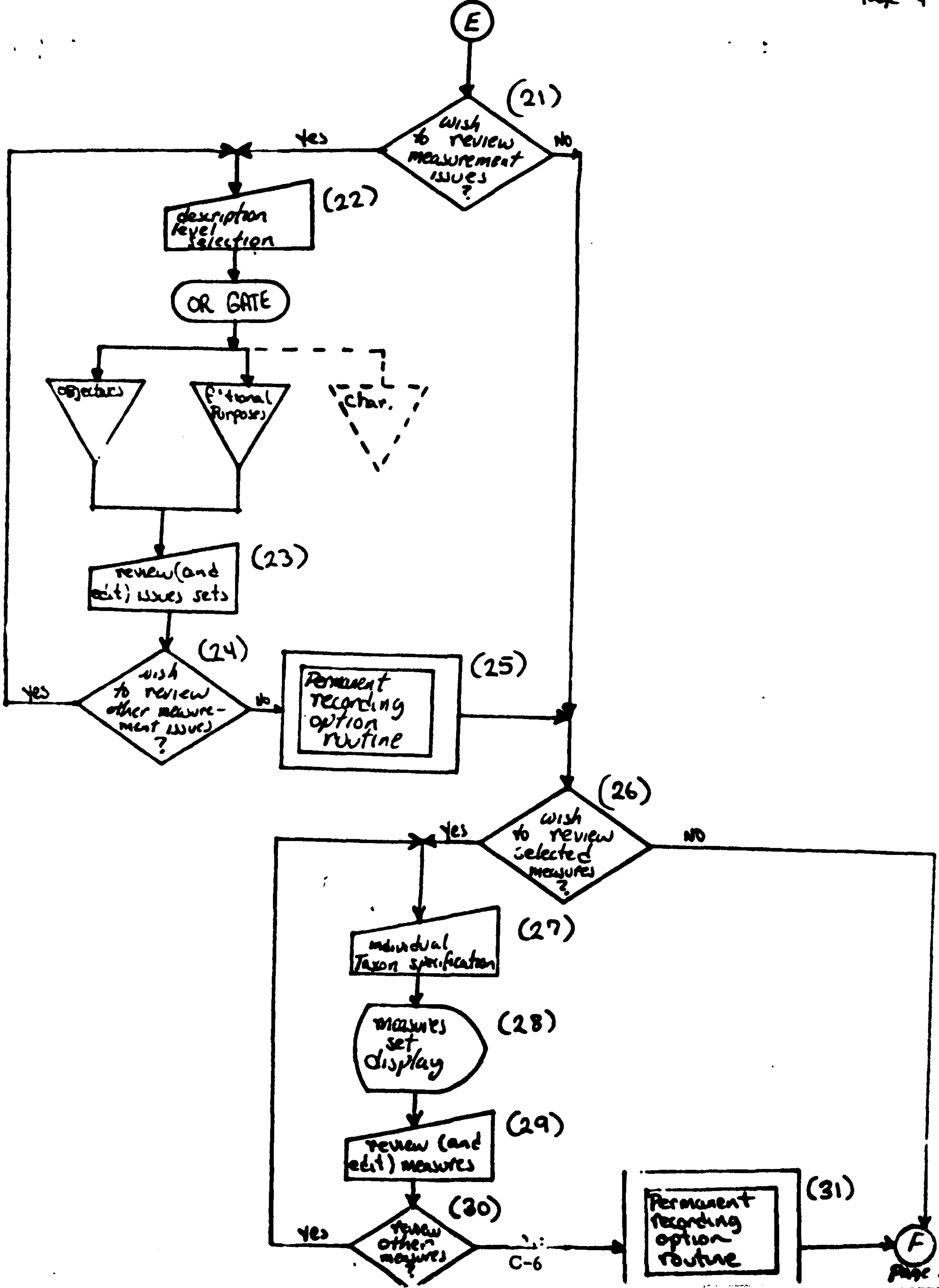
- Curriculum Development Subsystem
- Instructor Preparation Subsystem

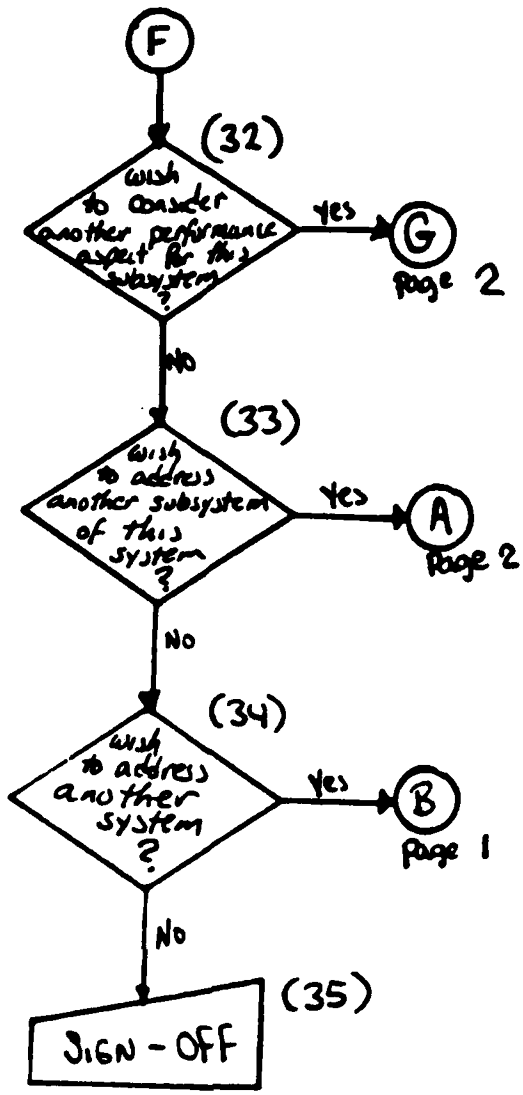

SIGN-ON
(1)
VIEW STM BASIC DESCRIPTIVE INFO ?
(2)
Yes
No
INFO DISPLAY
VIEW TYPES OF APPLICABLE SYSTEMS ?
(3)
Yes
No
B
SYSTEMS LIST
SYSTEM TYPE SELECTION
(4)
OR GATE
PERSONAL WEAPON
FIGHTING VEHICLE
TRAINING
TRANS-PORTATION
ATGM
APPLICATION SELECTION
(5)
OR GATE
SELECT MEASURES
SPECIFY DESIGN
A
page 2


A
SUBSYSTEM SELECTION
(6)
OR GATE
Curriculum d'ment
instructor prep.
Facilities d'ment
logistic sppt.
instruction deliv.
(7)
VIEW LIST OF PERFORMANCE ASPECT KEYWORDS ?
G
Yes
No
KEYWORD LIST FOR SELECTED SUBSYSTEM
(8)
PERFORMANCE ASPECT SPECIFICATION
(9)
Specified aspect in current keyword list ?
Yes
NO
(10)
wish to define taxonomy subset ?
NO
Page 5
F
Yes
(11)
designate taxa
(12)
wish to record taxonomy subset permanently ?
No
D
Page 3
Yes
C
Page 3


C
enter authorization code
(13)
(14)
Code valid ?
Yes
NO
Taxonomy subset permanently recorded
Subset
D
(15)
subset structure and size
(16)
wish to review taxa hierarchies ?
yes
NO
(17)
contextual category selection
OR GATE
Processes
Products
environment
constituents
(18)
review (and edit) hierarchies
(19)
wish to review other taxa hierarchies ?
Yes
NO
(20)
Permanent recording option routine
E

Page 4


E
(21)
wish to review measurement issues ?
yes
No
(22)
description level selection
OR GATE
objectives
f'tional purposes
char.
(23)
review (and edit) issues sets
(24)
wish to review other measurement issues ?
yes
no
(25)
Permanent recording option routine
(26)
wish to review selected measures ?
yes
NO
(27)
individual Taxon specification
(28)
measures set display
(29)
review (and edit) measures
(30)
review other measures ?
yes
(31)
Permanent recording option routine
F
page


F
(32)
wish to consider another performance aspect for this subsystem ?
Yes
G
Page 2
No
(33)
wish to address another subsystem of this system ?
Yes
A
Page 2
No
(34)
wish to address another system ?
Yes
B
Page 1
No
(35)
SIGN - OFF

EXPLANATORY NOTES

Page Number	Block Number	Block Name	Functional Description
1	1	SIGN-ON	Typical sign-on procedures for accessing an interactive computer system and specific software packages. Restricts access to STM to those who are authorized, i.e., those who know the sign-on code.
1	2	DECISION/QUERY: does operator wish to view some basic descriptive info about STM?	For the novice user, a capability will exist to access and review basic descriptive information about STM, e.g., its applications, its structure and data base, its interactive procedures, a list of more detailed references, etc. If the user so chooses, this information can be called up on the screen, in a series of display pages.
1	3	DECISION/QUERY: does operator wish to view the list of system types to which STM presently is applicable?	At any stage of its evolution, STM's data base will contain complete taxonomies for only a finite (but steadily growing) set of system types. Unless the user is interested in one of the types presently "stored" in the data base, STM will not be applicable to the user's needs. If the user so chooses, the list of presently "stored" types can be called up on the screen. **For the proposed demonstration, that list will include 5 entries, only one of which (Training Systems) actually will have taxonomies in storage.**
1	4	SYSTEM TYPE SELECTION	The user will type in the full name of one of the system types for which taxonomies presently exist in the data base. **For the proposed demonstration, even though four other choices will "appear" to be available, the user will have to select "Training".**
1	5	APPLICATION SELECTION	The computer will acknowledge the user's interest in the selected system type **(Training)** and inquire whether the user wishes to apply STM to 1) select MOEs/MOPs or 2) specify a system design. **Even though both options will be displayed, only 1) ... measures selection ... actually will be available for the proposed demonstration. Thus, the user will have to type in "1".**

Page Number	Block Number	Block Name	Functional Description
2	6	SUBSYSTEM SELECTION	The computer will acknowledge the user's interest in the specified STM application **(measures selection)**, and will present a list of the general or typical subsystems of the selected system type **(Training)**. The computer then will ask the user to indicate which subsystem is to be addressed first. **Even though all six general subsystems of Training will be displayed to the user, only two of them (Curriculum Development and Instructor Preparation) actually will have taxonomies in storage for the proposed demo.**
2	7	DECISION/QUERY: does operator wish to view the list of current Performance aspect KEYWORDS for the selected subsystem?	In any measurement application, the user typically is interested in assessing how well the system performs some particular aspect of its work. For example, one might be preparing to select MOEs/MOPs to investigate how well a curriculum development subsystem has performed with respect to producing specifications for testing learners. Each aspect of performance associates with some particular subset of the system's complete taxonomy. Each taxon in the subset gives rise to certain issues and implications for assessing the associated aspect of performance. At any stage of its evolution, STM's data base will contain specifications of the taxonomy subsets associated with a finite list of performance aspects for any given system/subsystem. Having signified interest in "Training" systems and (for example) their "curriculum development" or "instructor preparation" subsystem, the user can elect to call up display of a list of the performance aspects for the selected subsystem for which subsets of taxa are defined in the data base.
2	8	PERFORMANCE ASPECT SPECIFICATION	The user can type in any KEYWORD ... whether or not it exists in the current list ... to signify the performance aspect of interest. **For the proposed demonstration, the KEYWORD current lists for the Curriculum Development**

Page Number	Block Number	Block Name	Functional Description
2	8 (cont'd)		**and Instructor Preparation subsystems will be relatively short (approx. 10 entries in each). Further, actual subsets of taxa will be defined in the data base for only 2 or 3 entries in each list. One entry in both lists will be "TESTING", and taxa subsets will be defined for that entry.**
2	9	COMPUTER DECISION: is the performance aspect designated by the user contained/defined in the current KEYWORD list for the selected subsystem?	If the entered KEYWORD is not now defined (in terms of a designated subset of taxa), the computer will offer the user an opportunity to review the subsystem's complete taxonomy in order to identify those taxa associated with the newly specified performance aspect of interest. This is one example of how the applicability of STM can grow adaptively: a properly authorized user can define a new subset of the taxonomy, and this subset can be accessed in the future by other users interested in that same aspect of performance.
2	10	DECISION/QUERY: does the operator wish to define a subset of taxa associated with the previously undefined KEYWORD that has been entered?	Upon finding that the entered KEYWORD is not contained in the current list for the subsystem of interest **(Curriculum Development or Instructor Preparation)**, the computer notifies the user that an undefined aspect of performance has been designated, and inquires whether the user wishes to specify the taxa relevant to that aspect. If the user elects not to define a taxonomy subset, nothing more can be done concerning the undefined aspect of performance. STM defaults to the user, who can then choose to specify another aspect of performance, or address another type of system entirely, or simply commence SIGN-OFF procedures.
2	11	DESIGNATE TAXA (sequential procedure)	Upon receiving an indication that the user intends to define a taxonomy subset associated with the newly specified aspect of performance, the computer begins to display the specified subsystem's taxonomy to the user. The

Page Number	Block Number	Block Name	Functional Description
2	11 (cont'd)		concept here is that the user will make an "include or exclude" decision concerning each taxon's membership in the new subsystem. Experience suggests that it is sufficient to examine only the characteristics level taxa. If a taxon on that level associates with some aspect of performance, it automatically follows that its hierarchically superior taxa on the functional purposes level and the objectives level also must associate with the performance aspect. Thus, for example, if the user decides that taxon 1.2.4.1 (characteristics level) is relevant to the aspect of interest and signifies that the taxon is to belong to the subsystem being formed, the computer automatically will include taxa 1.2.4 (functional purposes level) and 1.2 (objectives level) in the subsystem as well. Thus, the computer will display every characteristics-level taxon to the operator, in sequence, and will "insist" that the user signify either INCLUDE or EXCLUDE before moving on to the next taxon. Once all characteristics-level taxa have been reviewed and designated for inclusion/exclusion, a subset will have been defined for the new performance aspect.
2	12	DECISION/QUERY: does operator wish to record for permanent storage the new taxonomy subset just defined?	The computer will not permit "casual" manipulation/modification of its data base of taxonomies, systems, subsystems, performance aspect subsets, etc. Any user can, at any time, define and operate on a new performance aspect and taxonomy subset. But the computer will not permanently store those data unless proper authorization is received.
3	13	ENTER AUTHORIZATION CODE	If the user desires to order permanent storage of a newly defined aspect of performance and its associated taxonomy subset, the user must type in a special authorization code. This is <u>not</u> the same as the SIGN-ON code. Only

Page Number	Block Number	Block Name	Functional Description
3	13 (cont'd)		special, designated users will have the authority to add or delete data in the permanent storage bases.
3	14	COMPUTER DECISION: is the code entered by the user valid authorization for permanent storage?	If the entered code is valid, the computer will enter the newly defined performance aspect and its associated taxonomy subset into permanent storage. Future users then will be able to access and use the subset. If the entered code is not valid, no permanent storage will take place, but the newly defined aspect and subset remains available for use by this user on this application.
3	15	DISPLAY: the structure and size of the taxonomy subset	The computer presents the user with a summary of the structure and size of the taxonomy subset associated with the specified aspect of performance. This will entail a listing of the numbers of hierarchies and individual taxa in each STM "column" associated with the specified performance aspect. A hierarchy, in this context, is a set of associated taxa, headed by one objectives-level taxon and followed by its descendants on the two lower levels, but including only those descendants that are relevant to the performance aspect of interest. For example, one relevant hierarchy might consist of: 1.2 1.2.1 1.2.1.3 1.2.1.4 1.2.4 1.2.4.2 1.2.4.3 1.2.4.6 That particular example depicts a hierarchy of performance potentiality taxa (leading digit = 1) containing 8 entries, namely, the second objectives-level "patriarch" (1.2), its first functional purposes-level derivative taxon (1.2.1), that taxon's third and fourth characteristics-level descendants

EXPLANATORY NOTES

Page Number	Block Number	Block Name	Functional Description
3	15 (cont'd)		(1.2.1.3, 1.2.1.4), the "patriarch's" fourth functional purposes taxon (1.2.4), and that taxon's second, third, and sixth characteristics-level derivatives (1.2.4.2, 1.2.4.3, 1.2.4.6). **For the proposed demonstration, a typical size/structure message displayed to the operator might appear as follows:** **SYSTEM: TRAINING** **SUBSYSTEM: CURRICULUM DEVELOPMENT** **ASPECT: TESTING** **POTENTIALITIES: 5 hierarchies 42 taxa** **PROCESSES: 2 hierarchies 10 taxa** **PRODUCTS: 6 hierarchies 44 taxa** This information conveys a summary of the scope of the measurement application at hand, and provides a "feel" for the distribution of measurement issues among potentialities, processes, and products.
3	16	DECISION/QUERY: does the operator wish to review, and possibly edit, the taxa hierarchies relevant to the specified aspect of performance?	The user may wish to examine the hierarchies and their constituent taxa. The STM data base "claims" that those hierarchies are relevant, in general, to the kind of measurement application at hand. However, the user might decide that certain taxa, or even entire hierarchies, are not really pertinent to the particular application and the particular system with which the user is concerned. Also, the user may have reason to believe that other taxa deemed not generally relevant are in fact of importance in this particular case. Thus, each user needs to have the ability to review and edit (through deletion or addition) the taxonomy subset generally associated with the performance aspect to insure that the subset is "tailored" to the user's particular application.

Page Number	Block Number	Block Name	Functional Description
3	17	CONTEXTUAL CATEGORY SELECTION	If the user signifies a desire to review and possibly edit the taxonomy subset, the computer inquires as to which contextual category of taxa the user wishes to review first. The choices correspond to the five columns of STM. **For the proposed demonstration, even though all five options will "appear" to be available, no taxa actually will be in storage for the "Environment Specification" or "General Constraints" categories. Thus, the demonstration user will be restricted to choosing one of the three "Performance" categories (Potentialities, Processes, or Products).**
3	18	REVIEW (AND EDIT) HIERARCHIES (sequential procedure)	Once the user indicates which contextual category of taxa is desired, the computer begins to display the hierarchies of the subset that belong to that category. **At each taxon, the user will be able to command a deletion. Such action will drop the indicated taxon (and its associated measures and measurement implications) from the set of taxa relevant to the particular measurement application. The user also will have the option of commanding an addition, i.e., the option of defining a new taxon and including it in the set of taxa for the particular application.** The user will review the entire collection of hierarchies in this fashion, indicating (at each taxon) whether to retain, delete, augment, or replace the various taxa. Thus, the hierarchies will be "tailored" to the user's particular application.
3	19	DECISION/QUERY: does the user wish to review/edit the hierarchies associated with another contextual category?	Having completed the review/editing of hierarchies in one column of the STM (e.g., Potentialities), the user will have the option of performing the same function for the hierarchies of another column (e.g., Processes or Products).
3	20	PERMANENT RECORDING OPTION ROUTINE	**Certain specially authorized users will have the capability of making permanent editorial changes to the data bases of hierarchies. This will be done**

Page Number	Block Number	Block Name	Functional Description
3	20 (cont'd)		**via entry of a special code number, in a fashion similar to that described in blocks 12, 13, and 14.**
4	21	DECISION/QUERY: does operator wish to review, and possibly edit, the measurement issues associated with the relevant taxa?	Up to this point, the user will have 1) specified the system and subsystem of interest, 2) defined the measurement application in terms of the specific aspect of performance of interest, and 3) selected the hierarchies of taxa that are relevant to that measurement application. The next step is to examine precisely what those taxa portend for that measurement application, i.e., the issues and implications for measurement associated with each taxon. Of course, if a particular taxon has been newly defined by the user, the computer will as yet have no associated issues for that taxon in storage. Thus, the user may wish to define such issues, and place them in storage.
4	22	DESCRIPTION LEVEL SELECTION	If the user signifies a desire to review and possibly edit the measurement issues associated with the selected taxa, the computer inquires as to which level of system description (objectives, functional purposes, or characteristics) the user wishes to review first. **Even though all three choices will "appear" to be available, the proposed demonstration will be limited to only the Objectives and Functional Purposes levels.**
4	23	REVIEW (AND EDIT) ISSUES SETS (sequential procedure)	Once the user indicates which level of system description is desired, the computer begins to display the taxa of that level, along with the measurement issues and implications associated with each taxon. **The user has the opportunity to edit those issues and implications, by deletion, modification, or addition.** Thus, the user can select precisely which issues will be addressed in the measurement application at hand.

Page Number	Block Number	Block Name	Functional Description
4	24	DECISION/QUERY: does the user wish to review/edit the measurement issues associated with another level of system description?	Having completed the review/editing of measurement issues in one row of the STM (e.g., Objectives Level), the user will have the opportunity to perform the same process for the issues of another row (e.g., Functional Purposes level or, **except for the proposed demonstration,** Characteristics level).
4	25	PERMANENT RECORDING OPTION ROUTINE	**Certain specially authorized users will have the capability of making permanent editorial changes to the data bases of measurement issues. This will be done via entry of a special code number, in a fashion similar to that described in blocks 12, 13, and 14.**
4	26	DECISION/QUERY: does the user wish to review, and possibly edit, measures applicable to selected issues?	This is the final, and most important, step in the STM application. It is at this point that a user extracts and/or defines specific measures suited to the performance aspect of interest. By signifying a desire to review the applicable measures, the user informs the computer that access to the data bases of measures is desired.
4	27	INDIVIDUAL TAXON SPECIFICATION	The computer responds by requesting the user to designate a relevant taxon from the (previously identified and—possibly—edited) subset. The user types in the taxon's number (two-to-four digits, depending on the level of system description). **For the proposed demonstration, no measures will actually be in storage for taxa on the characteristics level of system description. Thus, the demonstration user will be restricted to entering two- or three-digit taxa numbers.**
4	28	MEASURES SET DISPLAY	Once the user designates a taxon of interest, the computer responds by displaying all of the relevant measurement issues associated with that taxon, along with specific measures suitable for addressing those issues.

Page Number	Block Number	Block Name	Functional Description
4	29	REVIEW (AND EDIT) MEASURES	The user has the opportunity to edit the measures set associated with the sp ːified taxon, through deletion, modification, or addition. Thus, the specific measures selected can be "tailored" to the particular measurement application.
4	30	DECISION/QUERY: does the user wish to review/edit the measures set associated with another taxon?	Having completed the review/editing of measures associated with one member of the taxa subset, the user will have the opportunity to perform the same process for another taxon's measures. Again, for the proposed demonstration, only Objectives level and Functional Purposes level taxa actually will have measures sets available for review.
4	31	PERMANENT RECORDING OPTION ROUTINE	Certain specially authorized users will have the capability of making permanent editorial changes to the data bases of measures. This will be done via entry of a special code number, in a fashion similar to that described in blocks 12, 13, and 14.
5	32	DECISION/QUERY: does the user wish to address another aspect of performance for this same subsystem?	Once the user has reviewed/edited all measures of interest to the performance aspect previously specified, the computer inquires whether the user wishes to consider some other performance aspect as well. An affirmative response by the user causes STM to branch back to block 7 on page 2.
5	33	DECISION/QUERY: does the user now wish to address some other subsystem of this same system?	If the user indicates that no more work remains to be done in the context of the originally specified subsystem, the computer inquires whether the user wishes to consider another subsystem as well. An affirmative response by the user causes STM to branch back to block 6 on page 2.
5	34	DECISION/QUERY: does the user now wish to address some other system entirely?	If the user indicates that no more work remains to be done with any of the subsystems of the originally specified system, the computer inquires whether the user wishes to consider

EXPLANATORY NOTES

Page Number	Block Number	Block Name	Functional Description
5	34 (cont'd)		another system as well. An affirmative response by the user causes STM to branch back to block 3 on page 1.
5	35	SIGN-OFF	Typical sign-off procedures for terminating work with an interactive computer system. Permits storage of data processing in user-controlled memory files, initiates cost-accounting processing, etc.
			xxx